HOT WATER SUPPLY

A PRACTICAL TREATISE
UPON THE FITTING
OF HOT WATER APPARATUS

F. DYE

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HOT WATER SUPPLY.

HOT WATER SUPPLY

A PRACTICAL TREATISE

UPON

THE FITTING OF HOT WATER APPARATUS FOR DOMESTIC AND GENERAL PURPOSES

By F. DYE

THIRD EDITION

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1896

PREFACE.

THE chief object and aim of this work is to provide information for those who are but little acquainted with the subject, as well as for those who have some practical experience; therefore, care has been exercised to treat the subject in as clear and as simple a manner as is consistent with a really practical explanation. It is, however, hoped that some of the information given will be found of service even to skilled men, as the writer has had experience with all classes of workmen and works.

The want of such a work as the following has now been felt for a considerable time, and as hot water apparatus is now required in all classes of property, small as well as large, it is anticipated that the information contained herein will be of service also to architects, builders, and others who have to prepare specifications, estimates, &c., needed in connection with such undertakings.

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HOT WATER SUPPLY.

CHAPTER I.

BOILERS.

Boilers for the supply of hot water to baths, &c., throughout a building, are generally known by one of two names, viz., bath boilers or high pressure boilers. The latter term is certainly not a correct one (although it is most generally used of the two) as there is free escape for the steam, and there is no pressure exerted in the boiler except that which naturally exists by the weight of water that is in the pipes connected to it.

Iron boilers are most generally used, as they are the least costly; they are made of wrought plates welded (forged) at the seams. The plate varies in thickness from $\frac{1}{4}$-inch to $\frac{1}{2}$-inch, according to quality. The thickness that is found to give the best results for durability and general good qualities is $\frac{3}{8}$-inch plate. Figs. 1 and 2 are the forms most generally adopted for use in kitchen ranges, the position they occupy being at the back of the fire; this situation is the most economical as being a position in a range that cannot be well utilised for any other purpose.

The great point to be obtained with these boilers is the greatest possible heating surface. Fig. 1 is heated by the fire that comes in contact with it in front, also by the flame and heat that can be directed through the

arched flue which passes under the whole of its length; it therefore follows that the greater the length and width of this flue the better the results. These flues should not

FIG. 1.

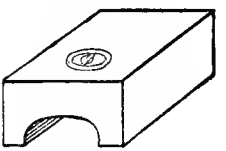
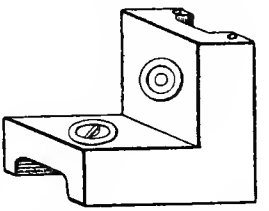


FIG. 2.



exceed $2\frac{1}{2}$ to 3 inches in height, as a high flue permits of too free an escape of the flame, &c., unless the boiler is unusually long. Fig. 3 will give the proportions to obtain the most effective results, this boiler being suitable for supplying about six draw-offs under ordinary circumstances; the height of the boiler is always governed by the height of the fire-box.

FIG. 3.

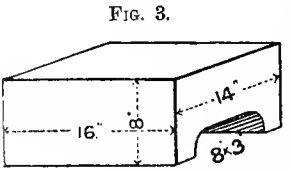


Fig. 2 is commonly known as a "boot"-shaped boiler, and differs from Fig. 1 only in having the "leg" added at the back; it will be understood that the object of this leg is to increase the heating surface and the efficiency of the boiler proportionately, but vertical heating surface will not give such good results as horizontal surface where the heat is applied underneath; this can be ascertained by a very familiar illustration, which is to notice the difference in heating a kettle of water by placing it either at the side or on top of the fire.

The flue up the back of a boiler should be contracted somewhat so as to make the flame come in actual contact

with the metal, as flame may be said to heat by contact only, and it may be mentioned that flame has a tendency to float *between* surfaces without touching them, wherever it is possible for it to do so; and another reason why this up-flue may be smaller is, that it has no likelihood of being choked with cinders and ash as the lower flue has; the effectiveness of this boiler can be increased by heightening the leg, but wherever possible it is decidedly better to increase the length and width of the boiler, for as before stated, bottom heating surface gives certainly the best results.

Boilers for use in London and the South of England must be provided with manholes and lids for the purposes of removing the incrustation which is formed from the chalky waters in these districts (*see* Boiler Cleaning); these lids should be of good size, easy to remove and repack, and above all *easily got at*. It is very necessary that not more than one piece of the range has to be removed to get at the boiler manlid, and in most modern ranges it is only necessary to remove a small *loose* plate. The manhole should be about 4½ inches diameter to admit of operating freely without discomfort or injury to the wrist, and preference is generally given to round lids, secured with the usual bridge with centre-pin and nut, as being more easy to pack; oval lids are frequently very troublesome to secure. An improved manlid is now being made which is fitted *wholly inside* the boiler from which two set pins pass through the boiler top and are secured by nuts, this admits of a rubber collar being used (instead of lead and hemp packing), and this cannot become injured by the action of the fire; it has the further important advantage that the higher the pressure put upon it the more secure the joint becomes, as the pressure it will be seen tends to press the lid more tightly against the inner top surface of the boiler; there is still another advantage in using a

rubber collar and that is if the boiler should accidentally become empty and then become red-hot (this is, as is very well known, *highly* dangerous, *see* Explosions and Causes), the rubber would quickly fuse and loosen the lid and so provide an outlet for the steam when the critical moment arrived, but it would not be well to place any great reliance on this. The rubber collar being inside the boiler does not so quickly get perished and consequently does not want frequent renewing.

There are many districts, chiefly in the north of England, where no material quantity of deposit occurs, and what is found is generally of a sandy or sometimes muddy nature. Boilers for these districts are not always provided with lids as they are not considered necessary; a hole is drilled in the bottom of the boiler and a good sized pipe (say 1½-inch) is provided for flushing purposes, this flushing effectually removing all deposited matter. In such districts "coil" boilers are commonly used as giving very good results; this consists of a coiled pipe (the same size and part of the circulating pipes) placed in the fire-box to serve the purpose of a boiler, but having the advantage of being *all heating surface*, its whole surface being in contact with the fire; this is a very efficient water-heater, more so than the ordinary boiler, as with the latter rarely more than half its surface can be exposed to the heat. A flushing pipe is taken from the bottom of the coil for cleaning purposes, and it will be understood that these coils are quite unsuited for water which has any perceptible quantity of lime in it, as the deposit from this adheres in a stone-like covering and would quickly fill the tube.

There are numberless other forms of boilers, but those named are most generally used and have by far the greatest share of favour, and it would occupy considerable space to treat them all fully.

Copper Boilers.

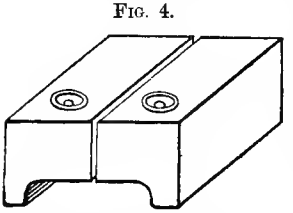
These are made of copper plates, varying in thickness; the same as with iron boilers, the plates being seamed and brazed at the joints instead of welded. Copper boilers are nearly always used in good works where cheapness in first cost is not the chief object, as they are to be recommended as possessing several advantages over iron boilers. They are much quicker heating, copper being a more rapid conductor of heat than iron; they are much more easily cleaned, as the deposit adheres to the surface to a very small extent, this is caused by the great power of expansion and contraction in copper which causes the incrustation to shell or scale off as fast as it is deposited; they do not discolour the water, they are far more lasting, and should the boiler get a thick internal coating of deposit the joints will not open as in welded iron boilers; and lastly, when a copper boiler is worn-out it is then as valuable as a new iron boiler, whereas a worn-out iron boiler is quite valueless. The cost of copper boilers is about four times that of iron, but varies greatly with the fluctuations of the market. Copper boilers, when fixed in kitchen ranges, should have a shield plate of cast-iron about $\frac{3}{4}$ to 1-inch thick placed in front of them for protection from the blows of the poker, the metal being softer than iron, or sometimes they are made with $\frac{5}{8}$-inch fronts and $\frac{3}{8}$-inch bodies, or $\frac{1}{2}$-inch fronts and $\frac{5}{16}$-inch bodies. If an iron shield is used it should be arched to correspond with and give clear passage to the arched flue of the boiler.

Twin Boilers.

It is sometimes found necessary to use twin boilers, that is, two boilers similar to one another working side by side with one fire; this is very rarely necessary and should be avoided wherever possible, although the old open ranges

were nearly always provided with two boilers, one for upstairs supply and the other for the kitchen requirements; it has now been finally decided that one boiler is ample for all purposes, and the water drawn in the servants' offices will in no way interfere with the supply of hot water in other parts of the building, the only occasion when there is any real need for twin boilers is when the cold water supply cistern at the top of a house is insufficiently large for the requirements of the whole building, so that concluding there is another cold water cistern in some lower part of the house two distinct boilers and services can be used, one for upstairs and one for downstairs supply, but *if it is at all possible* it would be far preferable to put a new larger cistern or an auxiliary one at the top, and so use one boiler, for the following reasons: where two boilers are used in one range the work that one has to do is sure to be either more or less than the other, consequently they should not be of the same size; it would take almost extraordinary judgment to arrange the size of the boilers so that they would work equally, and it may be said that in every practical instance it is found that one of the boilers is overdoing or else failing in its work; another objection is that it necessitates a larger fire-box to accommodate two boilers, and there is a consequent loss of fuel unless the boilers are sectional, as at Fig. 4, and in any case it is much more costly in fitting up.

FIG. 4.



INDEPENDENT BOILERS.

These are made in almost numberless shapes and forms much too numerous to mention here; but one care should be taken, and that is to see that the boiler is provided

with a large manlid, easily removable, if it is to be used with hard (chalky) water; manlids are not generally provided with these boilers, as they are commonly used for heating purposes only, in which case there is no appreciable deposit, as the same water is used over and over again.

Independent boilers are found of use in assisting the range boiler if large quantities of water are wanted early morning, and assisting the range boiler in winter if it has coils to heat up quickly; they are also found of convenience if hot water is required when the range is undergoing repairs, or the periodical boiler cleaning, &c. Independent boilers are usually only found of necessity in large establishments, institutions, &c. The method of connecting two boilers with one service will be found described later on.

There are various methods adopted in packing the manlids of range boilers, in fact, nearly every workman has some special feature of his own; a common method is to take some hemp and cut or chop it up, and thoroughly mix it with a stiff mixture of red and white lead, sufficient to make a bedding round the manhole where the flange of the lid comes, about $\frac{3}{16}$ inch thick; this, when the pressure is applied, is naturally made thinner, and part of it is squeezed out; before applying this packing the rim of the manhole and the flange of the lid must be painted with a mixture of red and white lead (to which is added *boiled* oil to make it liquid), as the first mixture will not readily adhere to the plain metal surfaces; if the manhole is one that has a bolt coming up through the centre, a ring of hemp, which has been soaked in the above liquid, must be slipped over the bolt before the nut is put on, to prevent leakage at this point.

Gold size is sometimes used in place of the boiled oil for very quick drying, but this is not to be recommended, as it is somewhat brittle when dry, and will not give to the

least extent without cracking. Commonly the hemp is coiled round the lid, upon the lead, instead of chopping and mixing it.

Another method, when hemp is not obtainable, is to get some soft loosely woven cord about $\frac{3}{16}$ inch thick, and thoroughly soak this in a stiff mixture of white and red lead and boiled oil, after which coil it round *flat* on the flange of the manlid, and bed it on with a little red and white lead mixture (there is a special rope-like material made for this purpose called "gaskin"). These methods are very old, and are inferior to the asbestos millboard; this is cut into collars or flanges the size of the manlid flange, it is soaked to soften it, and used without any further preparation, except to thickly paint the surface with a stiff mixture of red and white lead and boiled oil. Ordinary cardboard is sometimes used when asbestos is not obtainable; it is used in the same manner, but must be well soaked. Indiarubber flanges are now much used, but care has to be exercised to see that the manlid is not in a position where much fire-heat is felt, as this might destroy the rubber, as with the majority of boilers it has to be used outside, and not inside the boiler; these flanges are used without any preparation whatever, and come quite as cheap as any other method, as so much time is saved. They cost from 1*s.* to 1*s.* 6*d.* each, cut to order.

Boilers for the old pattern open ranges have been purposely omitted, as this style of range will soon be obsolete, and the space can be devoted to information of more value.

Before closing this chapter, it would be as well to mention that in districts that have hard waters, boilers should not have narrow water-ways, but should be as roomy as possible, that no part may become solid by incrustation. This subject of incrustation is an important one, as it can be said that in the south of England *three-fourths of the range-boiler failures are due to this cause.*

CHAPTER II.

CYLINDERS AND TANKS.

To decide what strength of cylinder or tank is to be used, it is necessary to measure and ascertain what pressure it will be subjected to when in use and charged with water. The pressure of water in pipes is 1 lb. to every 2 feet 4 inches in height in a pipe which has an internal area equal to a square inch, or, in other words, if you could have a block or body of water 1 inch square and 2 feet 4 inches high, it would weigh 1 lb.; it is only the perpendicular or vertical height that has to be calculated, so that, supposing the cold-water cistern (from which the cold supply is taken) is 14 feet above the tank, there will be a pressure of 6 lbs. (6 times 2 feet 4 inches) exerted upon *every square inch in the tank;* but it might be mentioned that the common practice is to calculate ½ lb. for every foot, this being the most ready way of reckoning. The pressure or weight of water in the pipe is, as before stated, felt upon every square inch in the tank or cylinder, as water has the peculiar property of transmitting pressure *equally in all directions, to the top, bottom, and sides of tank alike*—consequently it requires but a very short pipe to cause an enormous strain to be exerted on the tank, and this pressure is exerted the same, *whatever size of pipe the cold supply is*, for the following reason :—

If the cold supply pipe was 2 feet 4 inches high and had an internal area of 1 square inch, it would, when charged, cause a weight or pressure of 1 lb. to be felt on

every square inch in the tank; if the cold supply pipe was half of a square inch it would only cause a ½ lb. pressure, but this ½ lb. pressure would be felt on every half square inch in the tank, and consequently, as there must be just double the number of half square inches than there is whole square inches, the total pressure must be the same; or to illustrate it again, as the theory of equal pressure by any sized pipe is often disbelieved, let us suppose the cold supply pipe has an area equal to 2 square inches, this will cause a pressure of 2 lbs. to be felt, but not on every square inch in the tank; it will be a pressure of 2 lbs. upon every 2 square inches, and this it will be readily seen amounts to the same total pressure: so it may be relied upon that, if a tank is tested by the makers, and warranted to bear 5 lbs. pressure, it may be safely used where the cold cistern is 12 feet over the tank, whatever the cold supply is, or even a little higher, as it will be understood tanks and cylinders are never tested to the extreme pressure they are able to bear.

Tanks are only suited for comparatively light pressures up to 8 or 10 lbs., unless specially thick and stayed, and it will be found desirable—in fact, necessary—to use cylinders wherever the pressure is higher than this, their shape being much better suited for high pressures.

There is no objection to be made to using tanks wherever circumstances will admit of their being used, as their shape is in no way detrimental to the circulation of the water, as is sometimes supposed, and they are much cheaper than cylinders.

Messrs. Braby's list is as follows:—

	Cylinders.		Tanks.	
	Tested to	Average Thickness of Plate.	Tested to	Average Thickness of Plate.
No. 1	40 lb.	$\frac{3}{16}$ in.	10 lb.	about $\frac{3}{16}$ in.
Stocked „ 2	25 lb.	full $\frac{1}{8}$ „	5 lb.	„ $\frac{1}{8}$ „
„ 3	5 lb.	bare $\frac{1}{8}$ „	1 lb.	„ $\frac{1}{16}$ full

These are manufactured of wrought-iron plates, riveted at the angles with specially strengthened corners, and galvanised *after* manufacture.

The sizes most suitable for ordinary domestic requirements may be roughly calculated as follows :—

2	taps,	including	bath	.. ..	say	30 gallons.
3	„	„	„	.. ..	„	40 „
4	„	„	„	.. ..	„	50 „
6	„	„	„	.. ..	„	50 or 60 gallons.
8	„	or more,	including	2 baths	„	70 or 80 „

It is rare that larger than 80 gallons is required, except in fairly large business establishments ; it will be noticed that the above calculations only apply to the requirements of a private residence.

The packing of tank and cylinder manlids is carried out as with boiler manlids already described, but india-rubber flanges are still more strongly recommended for this purpose ; care should be used not to screw any one of the bolts up too quickly, that is to say, screw every one of the bolts up equally a little at the time, and when the lid is nearly bedded on, only give the bolts half a turn, or less, at the time. If this method is not adopted, the lid will be bedded on unevenly, and most probably will not be sound.

In ordering tanks and cylinders, if time will admit, they should be ordered with the flanges on ready for connection (four flanges—one each for flow, return, cold supply, and expansion pipes), as it reduces labour and time in connection, and makes a stronger and more workmanlike job of it ; but the fixing of flanges to order necessitates making a tank as the galvanising should be done after the flanges are affixed ; this occupies about seven or eight days. With cylinders it is almost absolutely necessary to have flanges affixed, as it is troublesome to make a sound

joint on the rounded surface of the cylinder, and at the best is poor and unsatisfactory, in fact, it should be a firm rule never to connect to the side of a cylinder without flanges. It might be mentioned that, if the cylinder is a high one, flanges *must* be used, as it is impossible to put back-nuts on to the pipes inside near the bottom, the only opening being at the top of the cylinder (the dome top being made to take off), unless a manlid is provided on the side, but this is not usual.

In conclusion, care should be taken to have the tank or cylinder quite strong enough for the pressure it has to bear, as, if too light, it will be a constant source of annoyance to the user and discredit to the fitter.

Copper cylinders are sometimes used, but have not received much favour in London, even in the most high-class works, as they are very costly, and need regular cleaning externally, otherwise their appearance becomes much worse than galvanised iron; they have the advantage of keeping the water clean, but very little more so than the galvanised; these latter, however, deteriorate, and fail in time, but the copper are practically indestructible with ordinary wear and tear. A copper cylinder has not so many good features to recommend it as a copper boiler has, the conditions under which they are used being so different.

Copper is also a more rapid conductor or dissipator of heat than iron.

CHAPTER III.

PIPES.

THE most general arrangement is iron pipe for the hot water (circulation and draw-offs), and lead pipe for the cold supply, but a still better arrangement is iron pipe throughout, and for the little extra expense it is desirable to have the pipes galvanised inside and outside; but it is contended that the pipe is somewhat injured by the process of galvanising, but this injury, if there is any, is certainly not appreciable. The advantage gained by using galvanised pipes is that the water is not discoloured by rust, but in fitting up this pipe no part of it must be forged, or the galvanising will be destroyed at this point; it is in the pipes where the greatest rust originates; the boiler does not make any material quantity after it has become a little furred.

The quality of pipe that should be used is that known as "steam tube," which, when galvanised, is known as "galvanised steam," and when not galvanised, as "red steam," on account of its reddish colour. Gas pipe (which is black in colour) is sometimes used in speculative and small property, but a firm of repute would not use it under any circumstances. It might be mentioned that when ordering "galvanised steam," care must be exercised to see that the right quality is sent, as it has several times come to the writer's experience that "galvanised gas" has been sent instead, as the former is not always stocked.

The most suitable size of pipes is as follows:—For the flow and return from the boiler, 1¼-inch pipes (internal diameter); for the service above the cylinder or tank, and for any other circulating service, 1-inch pipes; for the single pipe (branch) draw-off services, ¾-inch pipes, except to bath, which should be 1 inch, and to lavatory basins, which in most instances should be ½-inch; and the cold supply, 1-inch. There is an objection in having the draw-off services too large, as with the shortest single pipe there is always some cold water to draw off, and if any one had to empty the contents of a large pipe through a small lavatory cock, it would soon become an annoyance.

Most existing services that have been fitted up a few years will be found to have 1-inch pipes from the boiler; this size is now giving way to 1¼-inch, especially in districts where chalk exists in the water, and there are one or two firms in London strongly recommending 1½-inch pipes from the boiler, and 1¼-inch above the cylinder.

The advantages gained by having large pipes are, firstly, a freer circulation; and, secondly and most imimportant, their remaining in order a much longer period with hard water. An 1¼-inch pipe has about one-third more internal surface than a 1-inch pipe, consequently it would take a third of the time longer to get a ¼-inch coating of incrusted deposit in it. When this deposit has accumulated, the 1-inch pipe requires renewing, whereas the 1¼-inch pipe still has a ¾-inch bore, and is fit for more service; it can therefore be taken that an 1-inch pipe will fail in less than half the time that an 1¼-inch pipe would from this cause. ¾-inch circulating pipes are even to be found leading direct from the boiler, but nothing less than 1-inch should be used, even with the softest of waters.

The cold supply is commonly run in ¾-inch pipe, but this has an objectionable feature, which is, that if two

(or perhaps three) good sized taps are opened at once, they will not run very freely; this would be especially noticeable if the taps were situated in the higher part of the building, where the pressure is less; it is therefore best to use not less than 1-inch cold supply, unless the size of the apparatus and the requirements are very limited. Either wiped or blown joints are admissible in lead cold supply; many architects, &c., will not pass a blown joint, but a *good* joint of this description will never fail; but this only applies to the cold supply between the cistern and the tank or cylinder.

The method of jointing up iron pipes is as follows:— After cutting the required length and tapping the thread up it about 1 inch, paint the screwed part with a mixture of red and white lead and boiled oil, after which take a small quantity of hemp (say six or eight threads), and wind it round in the thread of the screw as evenly as possible; but care must be taken to wind it the correct way, or in screwing up the hemp will be unwound. The hemp should be wound on commencing at the extreme end, and *winding up the pipe;* before inserting the pipe, paint the inside thread of the socket, or whatever the pipe is about to be screwed into.

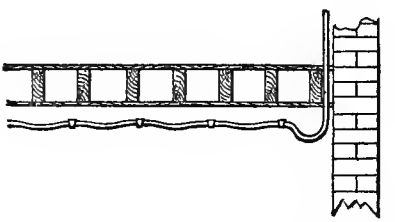
Make it an invariable rule to look through each pipe just before using it, to see it has no dirt or obstruction in it; and when leaving work unfinished, stop the open ends of the pipes with a plug of hemp, or anything convenient, to prevent dirt, &c., getting in, but be sure and take out this plug before the next pipes are connected. The use of *elbows* in circulating pipes should be avoided wherever possible, as they tend to check circulation, and are apt to collect deposit. *Bends* should be always used, but if it is absolutely necessary to use an elbow, see that it is a round elbow, as they are made both round and square at the angles; elbows can be used in draw-off services or in

expansion pipes where they are single and the water does not circulate in them.

Lead Pipes.—In many parts of the north of England *lead* pipe is used for the whole of the system right down to the boiler, but it will be found to have disfavour in the whole of the south, including London. It is certainly much easier, and takes less time to run than iron pipe, but of course the material is more costly, and there are two most serious objections; firstly, the ordinary plug-cock with a lever handle cannot be used, as the sudden shutting causes the pipe to swell and bulge into protuberances by the sudden pressure (or, properly speaking, it is the concussion) brought to bear; it is therefore necessary to use slow shutting (screw down) cocks, which are objectionable in many instances; the second disadvantage is that the pipes are known to fail from the following causes:—If the water is run out for any reason while the fire is in, or directly after the fire is extinguished, the heat retained in the surrounding brickwork is sometimes sufficient to melt the pipes; again, if the pipes become at all furred, as they do in the south (and as they do *not* so much in the north), the water does not freely come in contact with the metal, consequently the heat will act prejudicially upon them in the vicinity of the fire, and they will probably melt. Care must also be taken to well hook the pipes up, as the least jarring or unusual pressure will cause them to stretch and sag down where not supported, and this is particularly noticeable in vertical pipes which cannot be so strongly supported; as an example, an instance like the following met the writer's notice:—The flow-pipe was carried along the ceiling, and then directly up a casing to the highest part of the house. The vertical pipe was so badly supported, that its own weight would have been sufficient to stretch it, and the horizontal pipe was not sufficiently supported, also, consequently when it was

first called attention to about eight months after fitting, it was similar to the illustration (Fig. 5.) It is unnecessary to describe the awful results; such a flow-pipe could hardly be imagined. Still another and most serious

FIG. 5.



objection is that lead pipes cannot be used with soft waters, as most soft waters have a vigorous action upon lead, sufficient to render it unfit for drinking and general domestic purposes.

It will be found quite as cheap, and far more satisfactory to all concerned, to use a good quality iron tube, either the "red" or the galvanised steam. It will be understood that it needs a plumber to carry out lead hot water services, as only metal or wiped joints should be made. There are, however, instances in which lead pipes are almost absolutely necessary, and that is in districts in which the water is such as to cause plain iron pipes to oxidise and perish very rapidly, but galvanising the iron pipe will overcome this difficulty to a great extent.

Copper Pipes.—These are occasionally used, but do not possess sufficient advantages over galvanised iron to warrant the much greater expense; they are practically indestructible with ordinary care, and the same remarks as were applied to copper cylinders may be applied to copper tubes; plumbers' wiped metal joints are necessary,

as sockets and elbows, and the various fittings are not made in copper, except to order.

Iron pipes treated by the Bower-Barff process are gaining favour. The result of this process is to coat the pipe with an oxide that will withstand the action of any water; it is sometimes known as "rustless iron."

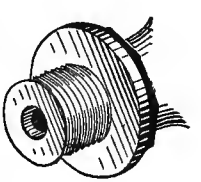
CHAPTER IV.

COCKS.

THESE are of a very varied design and make; and although it would be impossible to treat them fully here, yet there are many desirable features that should be mentioned. In the first place, let it be clearly understood that nothing will prove more annoying to the user and more disastrous to the fixer than a common quality tap. It is reasonable to infer that taps have not reached a state of perfection yet, for it would be difficult to guarantee any particular make of cock ($\frac{3}{4}$-inch) to withstand the wear it would be subjected to in the scullery of a large residence for more than twelve months without leaking.

For moderately low-pressure work, the gland cock or the ordinary plug cock with a lever handle, of good quality, will be found satisfactory; for high-pressure work the same description of cock may be used, but they must be "checked," to reduce the flow of water. This is done by making the bore in the screwed tail much smaller, as Fig. 6. This obviates any undue wear and tear, and it also prevents the violent outrush of water when the tap is opened, and the jar or concussion which follows if it is afterwards closed sharply.

FIG. 6.



Screw down cocks are generally considered as best adapted for high-pressure work, as the opening and closing

of the cock is necessarily slower than with plug cocks, but this slowness is the objectionable feature. This has been overcome by a more modern form of screw down cock, which has a quick or coarse thread. There are now several makes of these, which can be had to open or close with a quarter or half or one turn only; they should, however, be of reliable make, for as soon as the thread works at all loosely, the seating will lift by the pressure of water under it, and so cause a leakage. These cocks are, however, a step in the right direction, and undoubtedly have a good future.

Bath cocks should always be of large size, at least 1 inch, as a slow filling bath is very objectionable. The waste (emptying) pipe of a bath should be of large size also, that it may be emptied rapidly. A good feature in a bath is to have the hot water inlet at or near the bottom, so that it may quickly become covered with water when the bath is being filled, and so prevent so much steam being discharged into the room, which in a room of limited size is a source of annoyance.

Lavatory Cocks.—These should be of large size also, so that any stagnant (cold) water in the pipe may be drawn off quickly; the waste pipe should be large also, as with baths. Lavatory basins with a flushing rim are a great improvement, as they discharge the water into the basin through the rim, which is of great convenience for washing away the soapy sediment that is left round the basin after use.

Great care must be used to see that the stop-cock in the cold supply has a FULL WAY; that is to say, an 1-inch cock must have an 1-inch clear way through it when open, otherwise *the results will be as bad as having a small pipe throughout.*

CHAPTER V.

CIRCULATION, EXPLANATION AND CAUSE.

To clearly explain this subject, it is necessary to briefly describe the composition of water.

Water consists of an innumerable quantity of extremely minute particles, called molecules. These particles have the property of being able to glide over, under, and to or from each other almost entirely without resistance or friction. The action that takes place in a boiler is this: when the heat is applied, the particles nearest the heated surface become expanded or swollen, and are so rendered lighter (bulk for bulk) than their colder fellows, they are therefore compelled to rise to the highest point in the boiler; finding an opening there (the flow-pipe), they travel up this also until the highest point in the circulation is reached. It will be understood that immediately the expanded particles left the heating surface, other cold particles immediately took their place; these become heated in their turn and rise, following their predecessors, and so it continues. The circulation can be described as a stream of heated particles flowing up one pipe from the boiler, and a stream of cooler particles flowing down the other into the boiler; or it might be defined as a means of automatically transporting heated water from the lower to the upper parts of a building, and providing a down flow of cold water to the boiler to be heated in its turn.

From this description it will be seen that the flow-pipe should never start from the boiler in a horizontal direc-

tion, as this will cause considerable delay and trouble in starting the circulation. This pipe should *always* start in a vertical direction, even if it has to proceed horizontally within a few inches from the boiler. A few moments' reflection will show that the most perfect apparatus would be one that had the pipes carried in a direct vertical line between the boiler and the cylinder or tank; this is never, or but very rarely, possible, but ingenuity should be exercised to carry the pipes as near this direction as possible.

CHAPTER VI.

GENERAL DESCRIPTION OF APPARATUS.

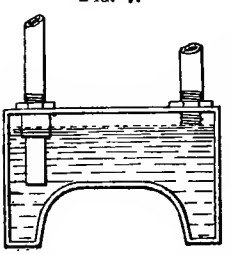
THE circulation is carried out by means of two pipes, the one up which the hot water ascends being called the flow-pipe, and the other by which the cooler or cold water descends being called the return pipe. When fixing a boiler in a kitchen range, it should be placed so that it is quite level or, what is better, a little higher at the back than at the front, as the pipes are always taken from the back, and it is absolutely necessary that the flow-pipe be taken from the highest point in the boiler. Taking the flow pipe first, this is carried from the highest point in the *top of the boiler* to about eight or ten inches up the side of the cylinder or tank ; if it is not convenient to take it through the side of the tank, it can be taken through the bottom with a stand-pipe about eight or ten inches high inside ; in carrying this pipe great care must be used to see that it does not descend or dip down anywhere in its course ; it can be carried horizontally wherever necessary but it should *be given a rise wherever it is at all possible to do so.*

Connectors (sometimes called long-screws, connecting pieces, &c.) should be used as freely as possible in all services, as at some future day it will be necessary to disconnect somewhere, and this provision will be found of great convenience, and probably save considerable damage and expense in cutting pipes, as the cut pipe must be renewed afterwards. Connectors should *always* be used

in attaching all pipes to the boiler, and to the tank or cylinder, and with every connector a back nut should be used to tighten up the running socket, and the connectors in the boiler and tank should each have two back nuts, one at each end, as the plate of the boiler or tank is not thick enough to make a reliable joint into.

This would be a favourable moment to explain why the flow pipe must not project through inside the boiler; supposing this flow-pipe projected inside the boiler say ½ inch (⅛th of an inch is enough to cause trouble) as at Fig. 7, when the apparatus was charged it would be found impossible to drive out the air from between the top surface of the boiler and the level of the bottom of this pipe, and the boiler would only fill up to the point shown in the illustration; this is all right while the water is cold, but when the fire has been lighted a little time, and steam is generated, this steam instantly rises and tries to displace the air, which in course of time it does, but not without a severe struggle which lasts a considerable time, and is not only heard, but frequently felt over the whole of the building. These remarks also apply in every sense to the pipe that is taken from the top of the cylinder or the tank (unless the tank is arranged not to fill quite full by means of a supply cistern).

FIG. 7.



Sometimes boilers are met with which have the flow pipe taken from the side or back, the expedient adopted in these instances to get the boiler full is to leave the manlid sufficiently loose when charging to allow the air to be expelled by the incoming water, the fitter being ready to tighten up the lid as soon as water runs freely from it.

In speaking of the flow-pipe, it is generally mentioned as running from the boiler to the tank (or cylinder), and the return pipe as running from the tank to the boiler; the return pipe is carried from the bottom, or from a low point in the side of the tank or cylinder (always from a lower point than the flow pipe) to about three or four inches down the boiler, either connecting it in the side or back of boiler, or passing it through the top and connecting a three or four inch piece on inside; this pipe generally follows the line of the flow-pipe, and to make a workmanlike job, it should be kept below it all the way; the remarks as to running and connecting the flow-pipe apply also to this pipe, except at the two extremities, as has just been explained, and as will be seen from the illustration; when there are any branch, flow, and return services, that from the boiler is known as the "primary" flow and return.

As has been already explained, the circulating pipes should be carried as much in a vertical direction as can be arranged with as little horizontal work as is possible, but regard must be had for appearances, as the pipes are not sightly at any time, and it is desirable to keep them well in the house.

Hot water pipes should, wherever it is possible, be kept away from outside walls, and they should never be allowed to come in contact with cold water pipes, or in other words, hot water pipes should be given the warmest position it is possible to give them, to prevent loss of heat by radiation and consequent loss of fuel, time, labour, &c.; the felting of pipes and other devices to prevent the heat being dissipated, will be treated later on, this subject is an important one, as it is almost barbarous to expend fuel and time in generating heat in the boiler, and then dissipating a good, and sometimes major portion of it where it is not needed; and should the hot pipes be brought in contact

with a soil (w.c.) pipe it is objectionable from another point of view, this is not an uncommon occurence, as it is frequently found necessary to run the pipes up the casing which contains the other service pipes of the house.

It might be here mentioned that in most residences, especially those of considerable height, a casing will be found which contains the soil pipes from the different w.c.'s, the waste-pipe from baths and lavatories, and the main cold water services; if there is room in this casing for the hot water pipes, and it is conveniently situated, it greatly simplifies the work, reduces the expense, and reduces the damage caused by cutting ceilings and walls, and it will be found that this casing is in almost every case carried close to where hot water is required, *but care should be taken to felt the hot water pipes* (*see* Loss of Heat and Causes).

We have thus far completed the apparatus from the boiler to the cylinder or tank; from the top of the cylinder or tank a pipe is carried up to just above the level of the cold water cistern, as will be seen illustrated; this pipe is known as the rising main or expansion pipe, and when the apparatus is charged, this pipe is full of water to about the level of the cold water in the cistern, the extremity of this pipe is either carried through a wall or roof, or turned over the cold water cistern, that the condensed water which sometimes drips from it may not do damage; and should the water be allowed to boil furiously, either through carelessness of servants, or the boiler being too powerful for the work, boiling water may occasionally be ejected.

The cold supply to the apparatus is brought by a direct service from the house cistern to the tank or cylinder; it is sometimes (though very seldom) found convenient with the cylinder system to take a branch from some existing cold service instead of bringing a separate service from

the top to the base of house, but this existing service must be of good size, and it must be from the highest cistern (if there is more than one), as you cannot expect to get hot water at a higher point than where the cold supply starts from, and it will be understood that a branch must not be taken from the water company's main unless a separate cold water supply cistern is going to be used.

There is a serious disadvantage in taking a branch service for cold supply, in the fact that there may be two or three taps in connection with this existing cold service and when the hot water apparatus is put in connection with it, there will be at least two to four taps more; if the existing cold service is only, say ¾-inch, it will be seen what annoyance will result if two or perhaps three taps are opened at once as they must necessarily run very slow, and this is particularly noticeable at the bath, where the two taps (hot and cold) are opened at once in nearly every instance, and in fact the hot and the cold taps wherever situated, are nearly always opened together to get the water at a moderate temperature.

Just before the cold supply pipe enters the tank or cylinder it must be dipped, or what is commonly called "syphoned," as shown in the illustrations; the object of this dip in the pipe is to prevent the water boiling back up the cold supply, which of course would be objectionable for several reasons; the dip should be about 12 to 18 inches deep. As it may not be known to all why this dip prevents boiling back, it may be explained that hot water being one-twentieth lighter than cold water, it cannot descend while the cold pipe remains charged with cold water; the specific gravity of freezing water, as compared to water at boiling point is as 20 to 21, but in domestic use the cold water averages about 50°, and the hot water about 160°, consequently the specific gravity is about as 40 to 41 or in other words, if the cold water cistern was 40 feet

above the cylinder, the rising main would be full of water to about a foot above the level of the cold water when the apparatus was in proper working order, and charged with hot water.

A stop-cock should be provided in the cold supply, whatever system is adopted, that the water supply may be shut off when the apparatus requires to be emptied for cleaning purposes or repairs, and a stop-cock does away with the unbusiness-like practice of plugging the outlet in the cold water cistern.

In the cylinder system it will be noticed that a special emptying cock has to be provided; *this and all stop-cocks should have loose keys, and these keys should be placed in charge of a responsible verson*, that they may not be used except for the purposes for which they are intended.

As before stated the stop-cock in the cold supply must have a *full way*, otherwise it will check the supply of water the same as if the cold supply pipe was smaller.

The following may appear a little stupid to many, but for those who have had no experience in water works it may be explained, that as before stated, hot water cannot be obtained at a higher point than where the cold supply originates, which is generally the house cistern at, or near, the top of the building; it is such a common thing to hear inexperienced people suggest that hot water can be drawn from a higher point if necessary, as it is somewhat commonly believed that the high pressure boiler *forces* the water up to any desired height, irrespective of the height of the cold supply.

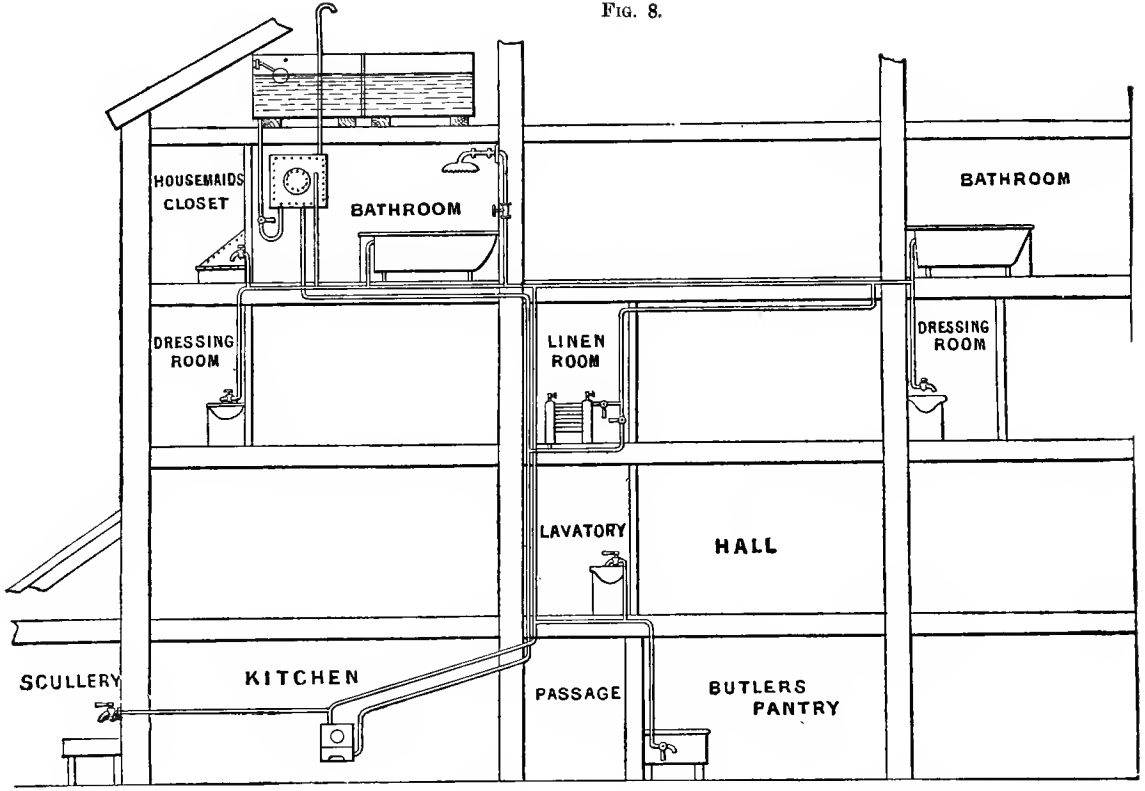
CHAPTER VII.

THE HIGH OR OLD TANK SYSTEM.

In this system a tank is invariably used, as only light pressures can exist; the tank, in nearly every instance, being situated above the highest draw-off.

Fig. (8) shows the general arrangement with this system. It will be noticed that the flow and return services are carried between boiler and tank. From the top of tank the expansion-pipe is carried some 4 or 5 feet above the level of the cold water in cistern, and the cold supply is brought into the bottom of the tank. All draw-offs are taken from the flow-pipe, and on the right side of illustration is shown a "returned" draw-off service. The advantage of returning a *long* draw-off service is that it permits the water to circulate through the pipe, and the annoyance of having to draw a quantity of cold water before the hot is obtained is overcome. It might be here mentioned that long single pipes are very objectionable, as it entails annoyance, as just explained, also waste of water (of material importance when it has to be pumped), also loss of heat, as, after drawing, the pipe is left full of hot water, sometimes some gallons or more, which cools before the next person uses the tap, and *this occurs every time the tap is opened.* A returned service is not of such great importance to a bath, as a certain quantity of cold water has to be drawn, consequently the quantity of cold water that would come from the hot tap with, say, a 30-feet single pipe service, could not be objected to; but the bath is the only

FIG. 8.


HOUSEMAIDS CLOSET
BATHROOM
BATHROOM
DRESSING ROOM
LINEN ROOM
DRESSING ROOM
LAVATORY
HALL
SCULLERY
KITCHEN
PASSAGE
BUTLERS PANTRY

place where it cannot be considered an annoyance and waste.

The "returned" portion of the draw-off service need not be so large as the draw-off service itself, as the only object aimed at is to keep the water moving.

To do the work shown in the illustration a flued boot boiler would be necessary, the fire not less than 11 inches wide, and the tank about 60 to 70 gallons.

CHAPTER VIII.

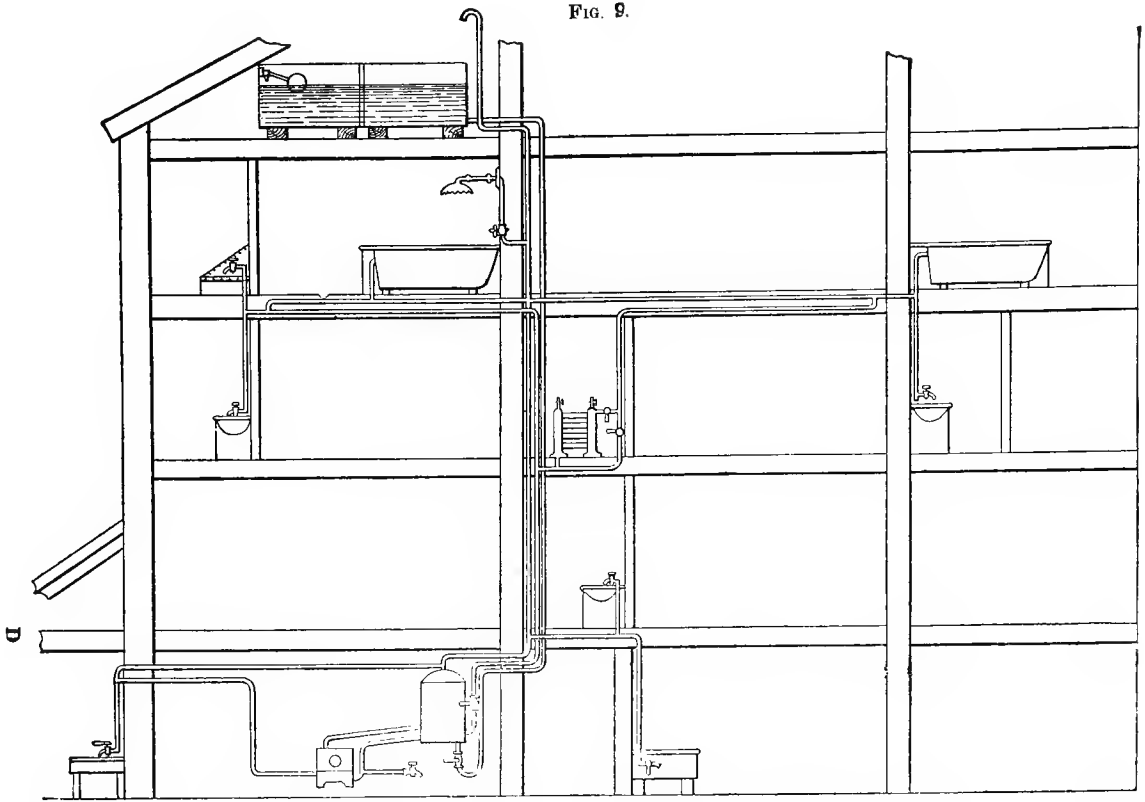
THE CYLINDER SYSTEM.

In this system a cylinder should be always used, as in a small apparatus the pressure is rarely less than 20 feet. The cylinder should be placed at the nearest convenient position to the boiler. Between the boiler and the cylinder is carried a flow and return, as shown at Fig. 9. From the top of the cylinder is carried the rising main to above the level of the cold water. If this rising main is not very long a single pipe is used only, but where the pipe is of good length, and other circumstances make it desirable, it is "returned," as shown. The rising main and its return is then known as the "secondary flow and return."

Where the rising main is attached to the top of the cylinder a flange must be provided for the first piece of the rising main to be screwed into, as the pipe must not on any account be screwed through the top to project inside, otherwise an air chamber will be formed, and ill results will be experienced, the same as if the flow-pipe projected through inside the boiler, as has been explained. The same remarks apply to the expansion-pipe from the top of a tank.

Draw-off services are all taken from the secondary flow (rising main), and any draw-off service can be returned, as explained in the high or old system. There are many who advocate the rising main being returned into the bottom of the cylinder, or into the bottom of the boiler, or into the primary return, but it will be found that the best

FIG. 9.



results are attained by returning it into about the middle of the cylinder a little higher than shown in illustration.

The secondary return need not be more than half the size of the secondary flow, as the only object of returning this pipe is to keep the water just circulating, and so prevent its becoming stagnant and cold, and no advantage is gained by the water circulating *rapidly* in this upper service; in fact it is a disadvantage, as there is a greater loss of heat by radiation.

This also applies to returned draw-off services, the return portion of which need never be more than a ½-inch pipe. *This, however, does not apply to the primary return.*

A stop-cock should be fitted in the secondary return (as shown in illustration) to prevent the water circulating at night. This keeps the hot water stored in the cylinder, whereas, if it is allowed to circulate all night, the heat will be nearly or quite all dissipated.

The cold supply is brought into the bottom of the cylinder with "syphon" and stop-cock.

This system, which is of American origin, is more modern than the preceding one, and is certainly preferable, having the following advantages:—Should the water-supply fail, the cylinder cannot be emptied, *as all draw-offs are taken from above the cylinder.* A body or quantity of hot water is obtained in less time, and the cylinder is in a warm position, so reducing loss of heat by radiation. The cylinder, however, should be cased and packed or felted, as it tends to raise the temperature of the kitchen, which might prove objectionable during hot weather; and in favour of the high system it must be said that hot water is obtainable very soon after lighting the fire, though only in small quantities.

It must be borne in mind that the chief of the failures are not due to the want of hot water for kitchen requirements during the day, but for want of hot water in quan-

tities the first thing in the morning for bathing purposes. A great assistance in obtaining this result is packing or felting the tank or cylinder and the pipes, and so keeping water warm over night; and there will be found an excellent combination of these two last-named systems that is also very successful. When an apparatus is properly fitted and finished it should give a warm bath in from thirty to forty minutes after first lighting the fire in the morning, and under favourable circumstances this time has been reduced to twenty minutes, with the tank and pipes well covered.

A special cock must be provided in the cylinder system for emptying purposes when cleaning or repairing (*see* illustration) this cock must have a loose key, as it should not be used except for the purpose for which it is provided, otherwise the chief advantage, the inability to empty the cylinder is lost.

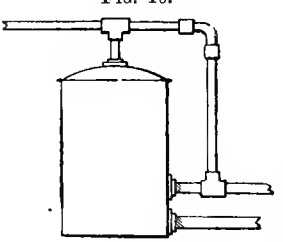
A flued boot-boiler would be necessary for the work illustrated, and the fire should not be less than 11 inches wide, the cylinder about 60 to 70 gallons.

CHAPTER IX.

IMPROVED SYSTEMS, ETC.

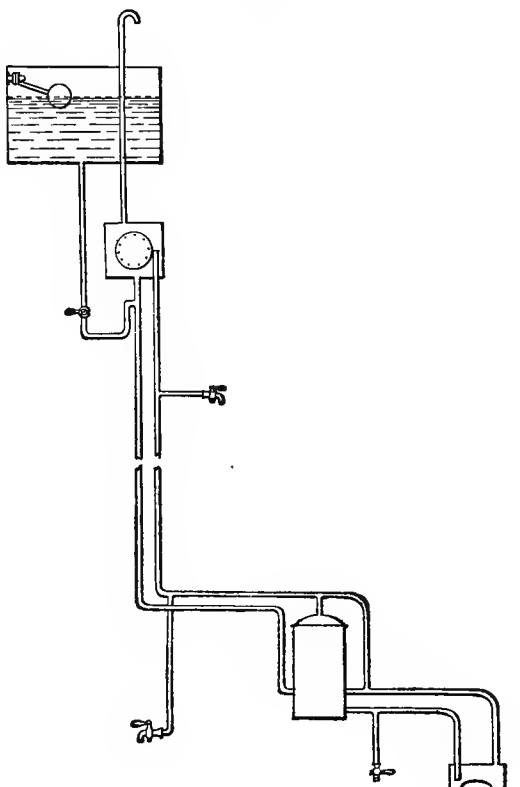
An improved method in connecting up the cylinder system is to carry a separate pipe direct from the primary flow to the secondary flow, as Fig. 10. This pipe should be of the same size as the secondary flow; the results are as follows:—When the water starts circulating it will be found to partly circulate directly up by the way of this connecting pipe, and to partly circulate into and through the cylinder, about half each way; the advantage gained is a more rapid circulation of hot water to the upper part of the building than is obtained with the ordinary cylinder system, while at the same time the store of hot water in the cylinder is being added to. The writer has practically tested this method, and considers that it is undoubtedly the best arrangement at present known. It is an adaptation of a portion of Dyer's system. A very good arrangement, but which, however, is just a *little* more expensive (?) is to have both a cylinder and a tank, as Fig. 11, thus fully combining the advantages of both systems without the disadvantages; both the cylinder and the tank should be smaller in this case, say 20 to 30 gallons each. All draw-offs should be taken off the secondary flow, and the cold water

Fig. 10.



in this instance may be taken into the bottom of the tank or into the secondary return, *thus avoiding the long cold supply pipe necessary in the cylinder system.*

FIG. 11.

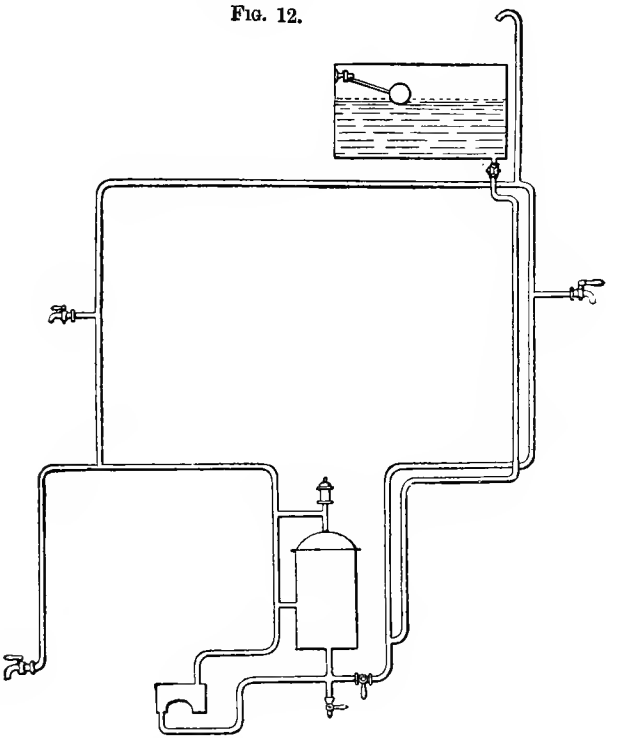


The secondary flow should be taken up to within, say eight inches, from the top of the tank, and whenever a tank is used the flow-pipe should be carried up a moderate

height, as it will now be understood that in a tank (or cylinder, or boiler) the hottest water will always be found nearest the top.

In some instances where a cylinder and tank are both

Fig. 12.



used, the flow-pipe is not connected to the cylinder at all, but goes direct from the boiler to the tank, this ensures hot water being obtained in the upper part of the building rapidly, but in actual practice it will be found preferable to connect to the cylinder, as last illustrated.

There are other methods that will be met with, but those treated will be found reliable, and will give excellent results, equal to any yet introduced.

Dyer's system, Fig. 12, will acquaint the reader with the principles of this system; it will be noticed that the cylinder is connected up in the manner recommended in the beginning of this chapter, in addition to which the return is carried down below the level of the boiler, and then up into the bottom; the object of this dip is to prevent water boiling back up the cold supply, as it will be seen that the cold supply is connected direct into the return pipe, close to the boiler, without the usual syphon; the results are exactly similar to those explained at the beginning of this chapter.

It will be understood that it is not necessary, neither is it usual, to bring the secondary return back by side of the secondary flow; this secondary service is most commonly returned by another route with the object of distributing the hot water taps throughout the building wherever needed, Fig. 12 will illustrate this; but in such an instance this secondary service should be of the same size throughout unless the draw-offs on the return portion are unimportant, in which case the return is run in smaller pipe, as explained in Chapter VIII.

CHAPTER X.

GENERAL DIRECTIONS; POSITION OF PIPES; CHARGING AND TESTING; DISCOLOURED WATER, ETC.

IT has already been explained that the circulating pipes should not be allowed to come in contact with any cold pipes, or waste or soil pipes; if it is desirable or convenient to make use of the casing which contains these pipes, the two sets of pipes must be kept separated, either by wooden wedges, or better still, by felting the hot water pipes, as this prevents loss of heat, &c. The pipes should, wherever possible, be carried up the inner walls, that is to say, not up the walls that form the outside of the building, as a severe frost might act prejudicially upon them, and it should be made a firm rule that pipes *never be carried outside a house*, even though they are afterwards well cased and packed, as should the range be out of use for, say 24 to 30 hours in frosty weather, all heat will in that time be out of the water, and the pipes will be found frozen solid, which is highly dangerous, and this has been known to occur in as short a space of time as one night only, although the pipes were most carefully covered.

Another practice that should be most carefully avoided is that of running pipes on to the brickwork in new buildings, and the plasterer afterwards covering them with his work; this is a too common practice when new buildings are being erected, and the results to the decorative work are most disastrous should a small leakage occur or any alteration be needed; it has sometimes been necessary to

seriously injure, if not actually destroy, most costly wall decorations on this account.

When an apparatus is completed, the next duty is to charge it with water, and to carefully inspect every joint, both in pipes and manlids, to see that all are sound, and afterwards to light the fire in the range or furnace, and see that satisfactory results are obtainable. Should a leakage be discovered it must be made good, however slight, and *not be left to pick up* (i.e., rust up); and as leaks cannot generally be rectified without disconnecting the pipe, the utility and convenience of connectors will be discovered. It might be here mentioned that none but inferior workmen leave leaks to pick up; it is a most unworkmanlike practice, and nearly always ends in the workman having to return to remedy some or all of these defective joints.

When charging the apparatus with water, all the cocks should be first opened to allow of the free escape of air as the water enters. If this precaution is not taken, there will be an accumulation of air at some point that will seriously interfere with the circulation, besides causing other unpleasantness. As the apparatus fills, and as each cock begins to run freely, it can be closed, and when the apparatus is fully charged the fire should be lighted. When the fire has been burning for some time, and the apparatus has become hot, the joints must all be *inspected again*, as the heat will often cause a somewhat imperfect joint to leak. A good plan, when the fire has been burning, say fifteen minutes, is to open a cock for half a minute —not the lowest one, but one on the first or second floor; this cock being in connection with the flow-pipe, its being opened will give a good start or impetus to the circulation in case it should be sluggish.

When an apparatus is first tested or used it takes considerably longer to get hot water than with an apparatus that has constant daily use, as everything in connection with

it and surrounding it is cold, and tends to retard the circulation. It can be taken that a quite new apparatus will take about 50 per cent. longer to heat the water to, say 150 degrees, than it will after it has had eight or ten days' use, as after it has got into proper working order everything surrounding it has become warmed, and the fire is never out for a sufficient length of time for the water to become actually cold.

If the work has been carried out in a proper manner a fairly good supply of hot water should be obtained after from $\frac{3}{4}$ to $1\frac{1}{4}$ hour firing when first testing. When the apparatus has had a few days' use this time should be reduced one-third, or even more, if the pipes and tank, &c., are in warm situations or felted, as the water is then kept moderately warm over night.

The user of an apparatus will sometimes complain that the water is discoloured. This is generally caused by rust, and the discolouration will disappear after a few days' use. Of course it will not occur at all if galvanised pipes and a galvanised or copper boiler is used; but in the most aggravated case the rust will stop as soon as a little fur is deposited on the different surfaces. Sometimes this discolouration proceeds from quite a different cause, it being a common occurrence in country residences where the water is supplied from ponds, lakes, &c. There is commonly in such cases a certain amount of sedimentary matter in the house water, however well it is *supposed* to be filtered. This sediment finds its way into the apparatus, and settles in the horizontal pipes and at the bottom of the boiler, tank, &c. The first time the water is allowed to boil, this sediment is agitated, and the water is rendered cloudy, if not absolutely dirty. This also occurs in many districts where the deposited matter from the water is of a sandy, muddy nature, and does not become incrusted as with chalky waters.

CHAPTER XI.

EXPERIMENTAL GLASS APPARATUS; RESULTS NOTED.

To those interested in this branch of mechanics the time and small outlay is well devoted to the construction of a small experimental apparatus in glass, &c.; the glass tube for the circulating pipe is very inexpensive, costing about a halfpenny per foot, and $\frac{3}{8}$ to $\frac{1}{2}$-inch glass tube can be easily bent in any direction by the heat of a gas flame or spirit lamp; the tee pieces can be made in zinc or copper, and reliable joints can be made with short pieces of india-rubber tubing a size smaller than the glass tube. The boiler can be made in glass by a glass-blower, at a small cost, or it can be made in zinc or copper; the cylinder can be easily provided either by a glass blower or by obtaining a short lamp glass about $4 \times 2\frac{1}{2}$ inches, like those used for small candle lamps, and making a metal cap to fit each end, and the cold water cistern can be made wholly in zinc. A difficulty that would present itself is how to make the water visible; this is overcome by putting a solid material (powdered) into it which has the same specific gravity, or weight, as water, and will neither float nor sink, but only move as the water moves, this material is amber; a portion of a pipe stem, filed or ground to a powder and stirred into the water, will be found to suffice admirably.

An apparatus of this description will be found a most interesting study, the heat is applied to the boiler by means of a spirit lamp, or by a small paraffin lamp, and by putting a blackened surface behind the pipes the results can be most accurately noted.

It should have been mentioned that draw-off services (say two) must be provided, and the only little difficulty or expense in connection with the whole undertaking is to obtain cocks of a proportionate size.

What induced the writer to make such an apparatus was that he once wanted a solution to the following problem, and although he asked far and wide, both good authorities and bad, he could not get one decided opinion, every one "*thought*" but none were decided, and strange to say, only an extreme minority were right.

The problem was as follows:—"When a tap is opened and water flows, from which direction does that water proceed, does it come up the flow-pipe from the boiler, or down the flow-pipe from the tank?"

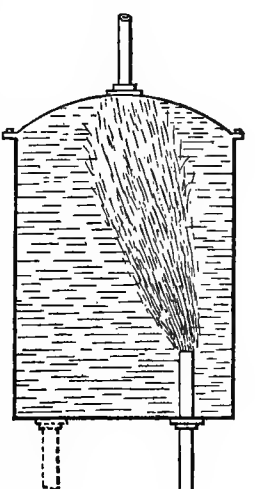
This was alluding to the old or high system; with the cylinder system, the question, of course, was worded a little differently, but to the same effect; it was found that the water proceeded about half each way, that is to say, when the tap was opened the water was seen to be flowing rapidly up the flow-pipe from the boiler, also down the flow-pipe from the tank at about equal speed. The reader will at once say, that the flow or current of water reversed itself in the flow-pipe between the tank and the draw-off service; it was so, but directly the tap was closed, the direction of the water *immediately* righted itself, and could be seen travelling placidly up the flow-pipe as it did before the tap was opened.

Another rather important result noted was that if the heat was not applied to the centre of the boiler (when first applying it and the water was cold) the water would commence circulating up whichever pipe the heat was applied nearest to, for instance, if the lamp was placed near or under the return pipe, the water without the least hesitation would commence to flow up this pipe, and the flow-pipe could be seen acting as the return; at first,

this was attributed to some accidental circumstance, but after repeated trials, each time starting with cold water, it was found that it happened the same on every occasion, it can therefore be inferred that if a workman was to bring his return pipe much nearer to the boiler flue than he did his flow-pipe, there would be every probability that a failure in the apparatus would result.

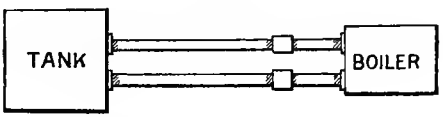
Another peculiar result noted quite confounds an usually accepted theory; it is commonly believed that in the cylinder system as at Fig 9, the water circulates between the boiler and the cylinder for a certain period before it commences to circulate in the upper or secondary flow; it is very commonly said that hot water cannot be expected in the secondary flow until a fair quantity of hot water is in the cylinder. This, however, is quite wrong, as a moment's consideration will show; it was found that immediately the water became heated it travelled up the flow-pipe from the boiler, thence into *and through* the cylinder up the secondary flow. There could be seen a distinct stream of water coming from the primary flow (in the cylinder), and this stream passed in a direct line to the outlet at top, as at Fig. 13. Very little, in fact, scarcely more than one-fourth of the heated water was retained in the cylinder, but there is no doubt that this stream of heated water passing through a body of cold water was robbed of a material quantity of its heat. Of course this does not take place when the rising main is not returned.

FIG. 13.



An experiment was also made to see if water would circulate *horizontally from the boiler*, as at Fig. 14, the object being to see if a small tank, say 10 or 15 gallons, could be placed at the side of a low-pressure range boiler to

FIG. 14.



increase the supply of hot water, as with many modern ranges the low-pressure or open-top side boilers are not sufficiently large; but it is to be regretted this experiment resulted in a failure, as although the water could be got to circulate, it was so slow and unsatisfactory as to be practically useless. By giving the pipes a little rise all went well, but with open-top boilers, of course, the pipes cannot be arranged so, as the water containers must be about level.

There are numberless, in fact, endless, pecularities to be noticed, but the above are a few of special importance, as being results which workmen are not generally conversant with.

CHAPTER XII.

INCRUSTATION AND CAUSES; BOILER CLEANING, ETC.

In all waters, especially in the south of England, there is a smaller or greater percentage of bicarbonate of lime. Bicarbonate of lime is lime charged with a double proportion of carbonic acid gas, that is to say, it has just double the quantity of carbonic acid to what carbonate of lime has; this renders it soluble in water to a very great extent, considerably more so than carbonate of lime is; water that issues from chalk strata is nearly always highly charged with this material and is commonly called "hard" water (although hardness in water proceeds from other causes than this). This water generally has a beautiful crystal-like clearness, and it will always be noticed that when the hardness proceeds from this cause, it is somewhat difficult to make soap lather in it. When this water is heated to boiling point, the excess carbonic acid gas is driven off and the lime is precipitated, and the heat and pressure cause it to adhere to the inner surface of the boiler in a hard stone-like covering, which is practically limestone.

This incrustation has more than one ill effect; firstly, it being a poor conductor of heat it materially interferes with the water heating as rapidly as it should do, and what is more serious, when it attains a certain thickness (varying with the porosity of the deposit) it prevents the water coming in contact with the iron, and consequently the iron perishes by the action of the fire, the same as an empty boiler would become destroyed. It can be said

without exaggeration, that seven-eighths of the boiler failures in London are solely due to this, and it is the cause of much misunderstanding between manufacturers and their clients.

There are now several preparations be to obtained for softening water by precipitating the lime in solution. These preparations necessitate the use of a separate cistern, as it will be understood that the deposited lime must not be allowed to pass into the house service pipes.

There is a somewhat common idea that filtering water will remove the lime, but this idea is wrong, as the lime is *in solution*, and passes through the filtering medium as freely as the water does; if soft water is not used, the only other means of saving the boiler is to have it cleaned out at regular periods; the period varies very greatly, depending upon different circumstances; it varies with the nature of the water, also with the power of the boiler, whether it causes the water to boil much or little, and it also varies according to the quantity of water used, as a certain quantity of water only yields a certain quantity of deposit, and the oftener the water is changed (drawn-off and replaced with cold) the greater the quantity of deposit. With London water it is found a desirable plan to clean out boilers every six months, this will keep the boiler in good order whether it has much work or little, but horn or cheek boilers, or any boilers with narrow water ways should be cleaned oftener, say every three or four months *regularly*.

Different circumstances govern the quantity of deposit, and it will be found to vary greatly even in two adjoining houses. A reliable plan is to let a boiler have, say four or six months ordinary daily use, and when it is opened after this period the thickness of the incrustation will determine whether the period of cleaning should be oftener or less often.

The reader will understand that this only applies to

boilers for hot water supply. Boilers that are used for heating purposes only are not provided with lids, as no appreciable incrustation takes place, *the same water being used over and over again.*

Country residences that have their water supply pumped from lakes, ponds, &c., rarely suffer with incrusted deposit, the deposit taking the form of earthy or sandy sediment; and where filtration is not carried out rigorously, small particles of leaves and organic matter find their way into the pipe system of the house; this is removed by periodical flushing of the pipes, tank or cylinder, and boiler, a good sized pipe being provided at the lowest point of the apparatus (bottom of boiler) for the purpose.

The deposited matter is seldom found to be alike in any two waters (there is even a noticeable difference in the London Water Companies' waters); but the deposit is practically of only two descriptions, viz. that which adheres or incrusts, and that which remains loose, and the method of disposing of these has now been explained.

The incrusted deposit is decidedly the worst to deal with, as not only is the boiler affected but the pipes also, and to rid the pipes of this matter they have to be taken down and heated and hammered, and this is nearly as costly as renewing the service; it however can be taken that the pipes will keep themselves in moderately good order, provided the boiler is cleaned at regular and frequent periods. The reader will now see the great importance of having good sized pipes with these waters, especially the pipes in proximity to the boiler.

It has already been explained that the incrusted deposit acts prejudicially in keeping the heat from the water; there is another ill result when the pipes become furred (incrusted), and that is, retarded circulation, and if neglected the pipes have frequently been known to become quite stopped (*see* Explosions and Causes.)

When cleaning a boiler of the incrusted deposit it will be found necessary to chip it with a chisel, held and worked by the hand; it is a laborious and tedious process, occupying from one to three hours after the boiler is opened, as it is most necessary to clear it all off the surface of the metal, especially where the heat is felt most, *also in the angles*, as this is where the seams of the boiler are, and in the majority of instances the fracture will be found to be an opened seam, this being the weakest point in the boiler.

CHAPTER XIII.

EXPLOSIONS AND CAUSES; SAFETY VALVES; FELTING AND PACKING PIPES, ETC.

THE causes of explosions at present known are—

1. *Failure in water supply.*
2. *Frost.*
3. *Stop-cocks.*
4. *Incrustation.*

No. 1 happens as follows: either from leakage, or some other cause, the supply of water in the house fails, perhaps during the night, and when the fire is lighted in the morning the boiler quickly empties itself by evaporation; when empty, it becomes red hot, and should the cold water then flow in an explosion must ensue, as steam is generated so very rapidly and in such volume, that the pipes are not nearly sufficient outlet for its free escape. This of course cannot occur with the cylinder system, as the contents of the cylinder cannot be drawn off, and of course it is at any time a rare occurrence, as shortness of water is nearly always noticed quickly; but an explosion from this cause once came under the writer's notice.

2. This cause, perhaps, should have been treated first, as it is the most usual source of such accidents. In both the cylinder system and the tank system the expansion pipes, which are provided for the free escape of steam, are generally situated in extremely cold positions, either in draughty roofs or outside; these pipes are more or less charged with water, and should this water freeze trouble

ensues; but the boiler would not explode unless the cold supply-pipe was frozen also, as when a moderate pressure of steam was developed it would force its way up this pipe if the expansion or rising main was closed; but if both pipes were closed an explosion in nearly every case takes place, as the steam is generated in the boiler faster than the ice will melt in the pipes.

In the tank system the danger lies in the flow and return pipe being frozen if on an outside wall or much exposed; if one pipe was clear there would be no danger, although some very unpleasant noises would be heard.

If the cold supply alone freezes there would be danger in the latter system, as the apparatus might possibly be emptied.

3. This was the cause of a serious disaster a very short time since, by which the practical man (a plumber) lost his life. In this instance stop-cocks had been put in both the primary flow and return, so as to be able to stop off all connection between the boiler and the cylinder when desired; the advantage gained in this is that when the boiler needs attention and opening, it is not necessary to draw the water out of the cylinder and apparatus generally; *but the principle of putting stop-cocks in these pipes is a terribly bad one.* A stop-cock in *one* of these pipes can *sometimes* be tolerated, but only when absolutely necessary.

In the instance just referred to, the man had done his work and, as is usual, lighted the fire to see all was in order, but he unknowingly had left the stop-cocks closed, and the boiler (having no safety valve), of course exploded when the steam had generated sufficient power to effect this.

4. This is a rare cause of explosion, although it would be a very common one but for the fact that before any actual danger is to be feared there is the most alarming

noises and symptoms brought about by the steam in its endeavours to get away up the choked and narrow passages.

There, however, comes to mind an instance in which a lady complained that most unpleasant noises had been heard in her range boiler for some time, and her further complaint was that now the safety valve (which was fortunately provided) was nearly always *leaking*. Upon investigation it was found that the flow-pipe was quite solid with incrustation, and the return pipe nearly so. The boiler had been in use about seven years without cleaning, and the reason that it was not burnt or cracked was that, although the quantity of deposit was very great, it was of a porous or spongy nature, which allowed of the water coming in contact with the metal sufficiently to protect it from the effects of the fire.

The reason that accidents of this description are so disastrous is, that before an explosion can take place there has to be sufficient steam power generated to burst the boiler, which is constructed of $\frac{1}{4}$-in. plates at the least, and a moment's consideration will show that, compared to this, the human body is a very frail object indeed, and suffers accordingly.

It is to be regretted that there are no regulations governing the safety of range boilers, and it is to be wondered at, that accidents are of not more frequent occurrence, as the manner in which cheap works are carried out, often by inexperienced people, is to be highly censured.

The most reliable remedy or safeguard against such accidents is a good quality safety valve properly fitted. There are many makes of these useful devices, all tolerably reliable, and considering that accidents can arise from such common-place causes, it is a good plan to advocate the use of them in every instance, as the cost is very low. There is a dissention as to the best position for the safety

valve, but as the accident always happens from the boiler, this certainly is the place for the valve, viz. at the seat of danger. Why people should advocate putting the valve in the tank or cylinder cannot be comprehended, but no doubt they have a reason, which reason, however, has never been satisfactorily explained to the writer.

Safety valves are practically of two kinds, viz. those that have the seating held down by a spring and those that have a weight or weights. They about equally share favour. The spring valve is the most compact, but, as every one knows, a spring does not last for ever; but, however the spring wears or deteriorates, it does not impair the safety of the valve, and it can be renewed at a very small cost.

As before stated, the correct place for a safety valve is directly in the boiler, but this can but seldom be put into practice as the valve should always be situated where it will be in sight and easily accessible for testing, &c. The most usual practice is to connect the valve with the boiler by a separate pipe, and this pipe should be of good size, so that it may not become furred up, and the workman, when cleaning out the boiler, should be instructed to see that the valve pipe is clear. An excellent method is being adopted by one firm, and that is to put the safety valve in the manlid, the valve being one that nearly wholly projects inside the boiler, it is then bound to have attention whenever the boiler is cleaned, and when the valve acts it obviates all further risk, as the water, &c., that escapes extinguishes the fire.

There is no little annoyance that sometimes occurs as follows: if a draw-off service is taken directly from the boiler (which should not be done), and this service has one of the ordinary sudden closing plug cocks, if this cock is closed sharply, the sudden stopping of the flow of water will in many instances cause the valve seating to lift

and a small quantity of water will escape each time. This can be remedied by putting a slow closing (screw down) cock in place of the quick closing one, but it is wrong to take any draw-off services direct from a high-pressure boiler, for other reasons that will be explained.

To set the Safety Valve.—After the apparatus is charged, the cap which regulates the tension of the spring should be unscrewed until it leaks, then tighten it up until the leakage ceases, after which give the cap one more turn to allow for any little extra pressure that may be developed when the fire is applied. A deadweight valve is set by the taking off or putting on the weights.

FIG. 15.

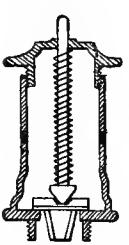


FIG. 16.

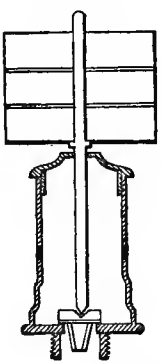


FIG. 17.

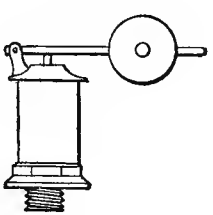


Fig. 15 is a spring safety valve. Fig. 16 is a deadweight safety valve. Fig. 17 is a safety valve with a lever arm.

FELTING AND PACKING PIPES.

This is a most important subject, but one of the most neglected; if fifty apparatus were examined about forty would be found having the pipes either exposed, or placed in wooden casings without anything covering them to

prevent heat being radiated ; the desirability of insulating the pipes can be impressed upon the reader by asking a simple question. Why should a proportion of the heat generated in the boiler be radiated or thrown away from the pipes? There is no reason whatever, as the object for which labour and fuel, &c. is expended upon the boiler is to provide hot water whenever desired, and not to diffuse a portion of the heat where it is not needed and not of the least service. In a well and carefully fitted apparatus, unless the pipes are insulated, at least one-sixth of the heat will be practically lost, and it is not an unusual thing to meet with an apparatus where the loss is much greater than this.

There are two usual methods of insulating pipes, the first is to cover them with felt by cutting sheet felt into strips, and winding it round spirally, afterwards binding it with string or wire ; this felt is specially prepared for this sort of work, and being made chiefly of hair, it is a natural non-conductor of heat and answers the purpose admirably, one thickness will be sufficient in ordinary protected situations, but in exposed places it should be doubled, so that when the apparatus is in full working order scarcely any heat will be felt if the hand is applied ; in addition to felting the pipes, the tank or cylinder must be covered also, as they present a very large radiating surface; the best method for these is to encase them, and pack the space between the tank and casing with cow-hair (plasterer's hair), but provision must be made for access to the manlid ; with the cylinder the insulation answers another good purpose, in keeping the kitchen at a lower temperature.

The other method of insulating the pipes is to encase them, and pack the space between the pipes and the casing with hair ; this has the best appearance, but is a little more costly.

There is a most serious mistake *often* made when casing pipes, and that is, failing to fill the intervening space with hair or any other non-conducting material; this is especially noticeable with a vertical casing, and is not an uncommon cause of the *utter failure* of an apparatus.

It will be readily understood that if the casing is not packed, and has badly fitted or open ends, this casing will become a flue immediately the water heats, as the air in contact with the pipes will be heated, and will rise, and cold air will flow in and it will be found that a continuous stream of cold air is passing into the lower ends of the casing, and the reader will at once see what an ill result this will produce. *It is imperative* that casings containing hot water pipes be packed, otherwise the apparatus will do better without them. Hair is the best material to use for this purpose, as it is a natural non-conductor, but there are other materials suited, such as slag-wool, sawdust, &c., &c.

There are many advantages gained by covering hot water pipes; for instance, you get hot water quicker, you may be assured that the boiler is giving its best results, it is decidedly economical, it has often been known to convert a badly working apparatus into a good one, and what is often considered of greatest importance, it will keep the water warm, and sometimes hot, over night; a carefully covered apparatus will give a warm bath before the fire is lighted in the morning.

Where the benefit of insulation is most felt is in instances where pipes are carried along stone passages, in cold roofs, &c., and when the tank is situated in the roof, &c.

This would be a favourable moment to mention that if anyone desires to leave a fire alight in the kitchen range the last thing at night, with the view of providing hot or warm water for the early morning, care must be used *not* to leave the damper of the boiler flue out; if it is left out

the water will continue heating for a time, but so soon as the fire burns low or goes out, the water will cool rapidly, as a swift current of cold air will be drawn under the boiler, and the water will be found quite cold in the morning. When a fire is left at night, the boiler damper should be *closed.*

It will be found extremely convenient, if the range has a means of making an open fire, as an open fire will remain alight a considerable time, and when burnt out the flow of air into the chimney does not act prejudicially on the water. As has already been mentioned the upper or secondary circulating service in the cylinder system, should be stopped (by means of the stop-cock provided for the purpose in the return) at night as the water in circulating around the house loses more or less of its heat, and the stopping of the circulation keeps a store of hot water in the cylinder.

No danger can arise from the misuse of this cock, and should it be left closed, in the morning the first person who draws water will have to empty the pipes of the stagnant water, and this will immediately show that the cock has not been opened.

CHAPTER XIV.

COILS AND COIL SERVICES; HOW TO CONVERT THE TANK SYSTEM INTO THE CYLINDER SYSTEM; HOW TO FIT A HIGH-PRESSURE BOILER TO BE USED FOR LOW-PRESSURE PURPOSES AT FIRST.

Coils are of two sorts; those made up of cast-iron pipes, and those made up by the hot-water fitter with his wrought-iron tube. The latter are only adapted for small purposes, such as for linen closets, towel airers, &c.; of course they could be made of any size, but where space is no object the cast-iron coils should be used, as they radiate the heat more freely.

Wrought-iron tube coils are of great convenience when awkward positions have to be contended with; they can be used successfully for warming the air that passes through inlet ventilators and for many other purposes where their small size and the endless shapes that they can be made in is found of great advantage.

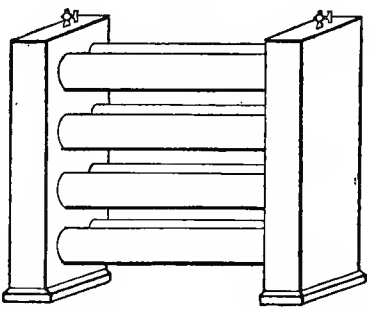
Cast-iron coils are now generally made up of two cast-iron box ends with rows of cast-iron pipes between them, as at Fig. 18. The pipes are jointed to the box ends by an indiarubber joint supplied by the makers. These are very expeditiously fitted, as there is no lead or hemp packing, &c., and the method is much superior (*for upright coils*) to the old style of making up the coil with cast pipes, bends, &c.

The subject of coils cannot be treated fully here, as they are really not desirable adjuncts to an apparatus for hot water supply, as the chief object of a coil is to dissipate

the heat, whereas with a hot water supply apparatus the heat should be retained in the water as much as possible.

Sometimes it is desired to heat a coil or row of pipes in a conservatory from a kitchen boiler. This can be done if

FIG. 18.



a sufficiently powerful boiler is provided for the work; *but it must be borne in mind that at the time at which the heat is most wanted in the conservatory the kitchen fire is out*—that is, at night.

The subject of heating and the most suitable sized coils for certain areas and under certain conditions cannot be given here; it can be found treated most exhaustively by Hood, Box, and other eminent writers; it, however, can be roughly calculated that a small coil, such as illustrated, would require boiler power equal to supplying two extra draw-off services.

Coils can be successfully worked in connection with a hot-water supply apparatus, provided the coils are only brought into use when hot water is not particularly needed, and provided heat is not required from the coils at night; as an instance, the writer once fitted coils in several bedrooms of a gentleman's summer residence, the object of the coils being to keep the rooms aired during

his absence in winter; hot water for draw-off purposes was little needed when the coils were working, as during his absence there were but two or three servants left in charge.

Of course coils can be, and are, worked from hot water

FIG. 19.

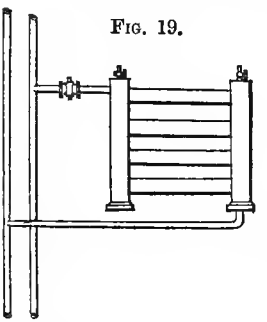
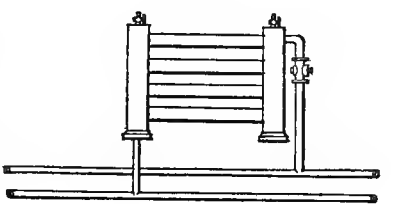


FIG. 20.



supply services at all times, but the general results are not altogether satisfactory, for, as just explained, the boiler must be increased in power considerably to compensate for the loss of heat, and in summer, or whenever the coils are not in use, annoyance is experienced by the boiler overdoing its work, &c., and the practice of working them off a supply service cannot be recommended as being good, unless the coil is a small one for some convenient purpose.

FIG. 21.

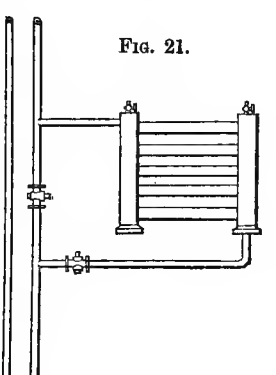


Fig. 19 shows a simple method when the service pipes are vertical, and Fig. 20 a method when the pipes are horizontal. Fig. 21 is another method, by which the flow

can be wholly diverted through the coil; but this cannot be recommended unless the coil is not required until after the water is heated in the morning, say 10 A.M.

Whenever it is at all possible, it is preferable to take a direct and distinct service from the boiler for coils and hot water pipes; this can either be done by taking a flow and return, or by taking a flow pipe only and making use of the supply return, as may be most convenient; a stop-cock would be necessary in the coil flow for the purpose of shutting off the circulation when not needed, and there should be a stop-cock in the coil service where it joins the supply return, as by means of these two cocks the coil service can be shut off entirely, and by providing a small draw-off cock at a low point, the service can be emptied of water, and so prevent rusting when not in use during the summer months.

Air cocks are needed at the highest points in coils, &c., to permit of the free escape of air when charging.

When any material amount of heating is required, it is much better to use an independent boiler, as by regulation a fire can be made to burn many hours without attention, so keeping up an even temperature during the night, &c.; these boilers are economical in use, and, as they burn coke fuel, there is no sweeping of flues, &c., needed. In many instances it is convenient to have a stop-cock upon each branch coil service, so that one or more of the coils can be rendered inoperative when desired, and yet not interfere with those from which heat is needed.

There is a modern form of coil now coming into favour and general use, called radiators; they consist of a series of ornamental cast pipes, either vertical or horizontal, and being of good design they can be exposed anywhere, whereas the general form of coil needs encasing if it is prominently situated.

The Conversion of the Tank System into the Cylinder System

is generally a simple and inexpensive matter. The most simple method of all is to disconnect the flow and return at a near point to the boiler, and insert the cylinder, connecting it up, as at Fig. 11; this increases the body of water in the apparatus, but this method should not be adopted if the boiler is only just powerful enough for the apparatus as it originally existed, as with the cylinder added the work is slightly increased.

Another method, when the apparatus is a small one, and the rising main from the top of cylinder need only be a single pipe, is to fit the cylinder in the method last explained; the portion of the flow-pipe above the cylinder can be utilised for the single rising main, and the remaining portion of the return pipe can be utilised as the cold supply to the cylinder. The flow-pipe must be disconnected at the tank and carried up to above the level of the cold water.

The return pipe need not of necessity be disconnected from the tank, if it is left, the tank acts as an auxiliary cold water cistern, but if it is desired to remove it the return must be joined to what was the cold supply to the tank.

A third method is to insert and connect up the cylinder as before, remove the tank, carry the flow up above the level of the cold water, and connect the return to the flow just above the highest draw-off service; this will then constitute a cylinder system with a primary and a secondary flow and return (the draw-offs remaining as they were). This apparatus will not be complete as there is no cold supply to the cylinder; this must be brought down by continuing what was the cold supply to the tank; this makes the conversion more expensive than the two methods before explained. If the boiler will admit of the little extra work, the first method will give just as good results without needing scarcely any extra pipe.

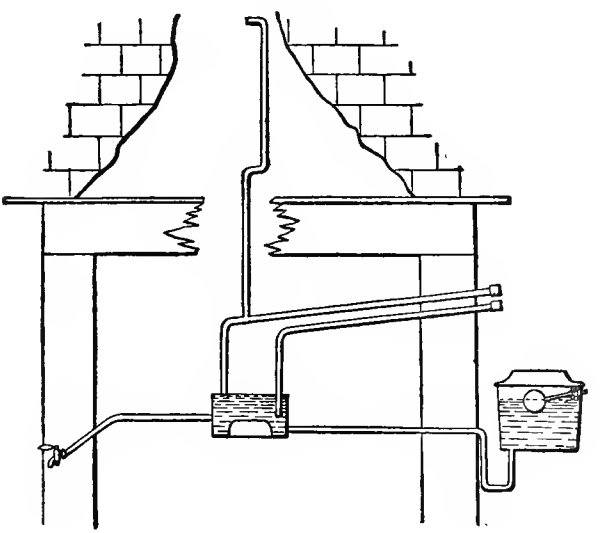
A client will often ask if he can have a high-pressure or circulating boiler (in a new range he intends purchasing), yet not use it for circulation for, say six months, as it is not convenient to have the service pipes instated until that time; this of course can be easily done, but it should be done in a manner that will admit of the service pipes being afterwards connected without pulling the range to pieces and creating unnecessary work and expense. The most perfect arrangement to obtain this end is to induce the customer to have the portion of the apparatus that is situated in the kitchen fitted up at once, viz. the primary flow and return, and the cylinder; this will not necessitate any cutting away, or pipe running out of the kitchen, and it will very greatly simplify the completion of the apparatus, as when the time arrives for connecting up, the fire will hardly need to be extinguished; this will also get over a difficulty experienced in using a high-pressure boiler for low-pressure purposes, first, and that is the smallness of the boiler (unless a boot boiler is used) and the consequent limited supply of hot water, and which limited supply boils most furiously.

If the apparatus is completed from the boiler to the cylinder, the cylinder can be fed by a small supply or feed cistern (with ball valve) placed at its side and connected with the nearest cold water service by a piece of half-inch light lead pipe, a steam escape pipe can be taken from the top of the cylinder, and carried to any convenient point, or turned over the feed cistern at the side; and this steam pipe if provided of the right size, can be afterwards utilised as the commencement of the rising main or secondary flow, a draw-off service can be taken off the flow from a near point of the boiler, and this draw-off can be afterwards used as the special emptying service by providing it with a loose-keyed cock, or with a cock that can afterwards have the key easily removed

This is the most complete and economical method, as when the conversion takes place only the temporary cold supply has to be disposed of, and the range has not to be interfered with in any way whatever.

Another cheaper method, but which entails more excess work when converting, is to fit the boiler and construct the flue to it (the same as if it was to be used for high-pressure purposes) and connect and carry the flow and return from the boiler to just outside the chimney jamb and there cap them off, as Fig. 22. From the first

FIG. 22.



bend in the flow a steam pipe must be carried up, say six or eight feet, or even higher; the cold water must be brought in the side as with low-pressure boilers, and the draw-off taken from the side also, as shown in the illustration.

The flue from the boiler should be made in readiness for high-pressure purposes, but until the conversion takes place it must be stopped; this is best done by cutting a piece of fire brick to the shape of the flue under the boiler and cementing it in, it can then be easily removed when desired, leaving the flue clear and ready for use. Should the boiler be small and the water boil furiously it may be found necessary to place a piece of thick cast plate, or fire brick, in front of it to check its heating somewhat.

The steam escape pipe should be carried to a good height, as with such rapid boiling, water may be ejected, more especially if the boiler fills nearly full. To prevent water being ejected from the steam pipe, the boiler should not be filled to the top by four inches, or at the least three inches, but *this can only be done with boot-boilers*, as it would not be wise to leave three or four inches of the boiler empty where it comes in contact with the fire, therefore, if a square boiler is used, as shown in the illustration, a crank or set must be made in the steam pipe, the boiler can then be filled within, say half an inch, as any water shot up the steam pipe will strike the crank and go no further. (It is often desirable to put this crank in the expansion pipe from a tank.)

When the conversion takes place it is necessary to unstop the boiler flue; take the caps off the flow and return, and connect up; take out or cap off the steam escape pipe; and take out or cap off the cold supply; the draw-off service will fulfil the part of the special emptying service. This service should have a loose-keyed cock.

CHAPTER XV.

ESTIMATES AND ESTIMATING; TOOLS.

THERE is no branch of mechanics in which estimates are so much required, and given, as in hot water fitting, therefore it is very desirable, in fact necessary, to have a good knowledge of general details for approximating the time that will be occupied. It is comparatively an easy matter to get at the correct quantities and value of materials that will be needed, but there are many sundry expenses that are apt to be overlooked, especially if the work is in the country, and be as careful as you may, it is very desirable to put down a sum for incidentals.

The writer much regrets that he cannot give any fixed rule or data for judging the time that should be occupied on any particular job, as it does not follow that a small apparatus will necessarily occupy but a short time or *vice versâ*; it depends upon the number of joints that have to be made, the number of turns, and directions in which the pipe has to be run, the quantity of cutting away, &c., &c.

An example of a very ordinary estimate is here given, and it will be seen that this is a most simple method of arriving at the cost, with the advantage of showing the exact quantities to provide when the order is secured; it also has the further advantage of showing clearly if everything is included, if any one draw-off service was omitted it would be noticed instantly; the system of showing every service separately is decidedly better than calculating

all the services of one size together, as with the latter method a slip of the memory cannot be afterwards noticed, and in these days of keen competition it is very essential that nothing be forgotten.

The prices in the following estimate are net cost. A list of tubes and fittings will be found further on in this chapter; this list is adhered to by all makers, and at the present moment is subject to 52½ per cent. discount for red steam tube, and 30 per cent. for galvanised steam in small quantities.

It will be noticed that the items here shown are only those in connection with the hot water apparatus, and do not include the time and expenses in connection with fixing a range, nor adapting a boiler to an existing range, as this portion of the work varies so greatly.

When ordering pipes, order "*some short lengths from* 2 *feet to* 6 *feet,*" as the cost is the same, and it will frequently save a cut and save buying sockets; the manufacturers nearly always send all long lengths unless ordered otherwise.

ESTIMATE: NET COST.

		£	s.	d.
Boiler.	1 boiler, say	1	15	0
Cylinder.	1 50-gallon galvanised cylinder, ⅛ in. plate, fitted with flanges	2	10	0
Primary flow and return.	8 ft. 1¼-in. red steam tube at 5½*d.*	0	3	8
	4 1¼-in. connectors at 7½*d.*	0	2	6
	8 1¼-in. backnuts at 3*d.*	0	2	0
	2 1¼-in. bends at 10½*d.*	0	1	9
Secondary flow.	55 ft. 1-in. red steam at 4½*d.*	0	19	6
	4 1-in. connectors at 6*d.*	0	2	0
	4 1-in backnuts at 2*d.*	0	0	8
	8 1-in. bends at 7½*d.*	0	5	0
	2 1-in. round elbows at 8*d.*	0	1	4
Secondary return.	45 ft. ½-in. red steam at 2½*d.*	0	9	5
	4 ½-in. connectors and nuts at 5½*d.*	0	1	10
	6 ½-in. bends at 4*d.*	0	2	0
	2 ½-in. elbows at 4½*d.*	0	0	9
	1 1-in. × ½-in. tee	0	0	8
	1 ½-in. stop-cock (loose key)	0	2	9
	Carried forward	£7	0	10

		£	s.	d.
	Brought forward	7	0	10
Cold supply.	54 ft. 1-in. red steam at 4½*d.*	0	19	2
	4 1-in. connectors and nuts at 8*d.*	0	2	8
	8 1-in. bends at 7½*d.*	0	5	0
	2 1-in. elbows at 8*d.*	0	1	4
	1 1-in. full way stop-cock	0	6	6
Scullery sink draw-off.	12 ft. ¾-in. red steam at 3*d.*	0	3	0
	2 ¾-in. elbows at 6*d.*	0	1	0
	1 ¾-in. connector and nut	0	0	7
	1 1-in. × ¾-in. tee	0	0	8
	1 ¾-in. G.M. bib-cock	0	6	0
Butler's pantry.	8 ft. ¾-in. red steam at 3*d.*	0	2	0
	2 ¾-in. elbows at 6*d.*	0	1	0
	1 ¾-in. equal tee	0	0	6
	1 ¾-in. G.M. bib-cock	0	6	0
Housemaid's sink.	2 ft. ¾-in. red steam at 3*d.*	0	0	6
	1 ¾-in. elbow	0	0	6
	1 1-in. × ¾-in. tee	0	0	8
	1 ¾-in. G.M. bib-cock	0	6	0
Lavatory.	10 ft. ½-in. red steam at 2½*d.*	0	2	0
	1 ½-in. connector and nut	0	0	6
	3 ½-in. elbows at 4½*d.*	0	1	2
	1 1-in. × ½-in. tee	0	0	8
	(Lavatory fitted with cocks.)			
Emptying service.	1 tee, 10*d.*; 3 ¾-in. tube, 9*d.*; 1 cock, 3*s.* 6*d.* ..	0	5	1
Bath service.	14 ft. 1-in. red steam at 3*d.*	0	3	6
	3 1-in. round elbows at 8*d.*	0	2	0
	1 1-in. connector and nut	0	0	8
	1 1-in. equal tee	0	0	8
	(Bath has own cocks.)			
Time.	Say 95 hours, 2 men at 1*s.* 2*d.*, including time travelling	5	10	10
	Rail fares, say	0	15	6
	Country expenses (if in country), 10 days at 1*s.* 6*d.* per day each man	1	10	0
	Foreman's time and fare estimating	0	14	6
	Carriage of cylinder and materials	0	6	6
	Red and white lead, oil, hemp	0	3	0
	Use of tools	0	3	6
	Building materials for making good cutting away, mortar, cement, and plaster	0	5	0
	Coals for testing (if in new building) and other sundries and incidentals, say	0	10	0
	Total net cost	£20	19	0

If a country job, arrange for customer to do all cartage of men, tools, and materials to and from station and

residence. If customer cannot arrange this, a sum varying with the distance and quantity of materials must be added.

The actual cost of work varies to a considerable extent under different circumstances. Workmen differ greatly in their business capacity, and the writer has fairly tried both high and low priced men with the result that the former of the two are the cheapest in the end, with the advantage of giving satisfaction and gaining the client's good opinion; yet, under some circumstance, cheap men can be employed, especially if a sharp foreman is kept who can be often with them.

It will be found that, unless the undertaking is of any magnitude, it will be cheaper to put two men only to execute the work (fitter and labourer) as it will be found that with four men, however tried and trustworthy they are, the job will become more expensive, even supposing they can work on different parts of the apparatus without interfering with one another.

Tools.—A hot water fitter's kit of tools consists of the following articles, which should be all of *really good quality*, as many know by experience that common tools (which are made of inferior metal, and are not as hard and wear resisting as good steel, &c.), if only costing one-fourth the price of good, will be found to wear much too rapidly to be economical, not taking into consideration the inferior work that must be done (this remark particularly applies to stocks and dies):—

1 set "Patent" stocks and dies, to take from ½ in. to 1¼ in., with guides.

1 wheeled tube cutter, to take up to 1¼ in.

1 "Sampson," or pipe-vice.

1 pair tongs each ½ in., ¾ in., 1 in., 1¼ in., 1½ in.

(The 1½ in. tongs are for 1¼ in. sockets and fittings.)

1 tube wrench or "dog." This is especially useful for

Internal Diameter.	⅛	¼	⅜	½	¾	1	1¼	1½	1¾
TUBES.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Tubes, 2 to 14 ft. long, per ft. ..	0 2	0 2½	0 3	0 4½	0 6	0 8½	0 11	1 2	1 6
Pieces, 12 to 23½ in. long each	0 4	0 5	0 7	0 9	1 0	1 4	1 8	2 0	2 6
„ 3 to 11½ „ „	0 2	0 3	0 4	0 6	0 8	0 11	1 1	1 4	2 0
Longscrews 12 to 23½ in. long „	0 5	0 7	0 9	0 11	1 2	1 6	2 0	2 6	3 3
„ 3 to 11½ „ „	0 4	0 5	0 6	0 8	0 10	1 0	1 3	2 0	2 6
Bends .. .. „	0 5½	0 6½	0 7	0 8	0 11	1 3	1 9	2 3	3 3
Springs, not socketed .. .. „	0 4	0 5	0 6	0 7	0 9	0 11	1 4	1 8	2 6
FITTINGS.									
Elbows, wrought-iron .. .. each	0 6	0 6½	0 7	0 8	0 10	1 2	1 9	2 3	3 0
Tees „ .. .. „	0 6	0 6½	0 7	0 9	1 0	1 3	1 9	2 6	3 0
Crosses „ .. .. „	0 10	1 0	1 0	1 5	1 9	2 3	3 0	3 6	4 6
Plain sockets .. .. .. „	0 1½	0 1½	0 2	0 3	0 3½	0 4	0 6	0 7	0 9
Diminished sockets .. .. „	..	0 3	0 4	0 5	0 6	0 7	0 9	0 11	1 1
Flanges .. .. „	0 8	0 9	0 10	1 0	1 2	1 4	1 6	1 9	2 0
18 Caps, 19 Plugs .. .. „	0 2	0 3	0 3	0 4	0 5	0 6	0 8	0 10	1 0
20 Backnuts, 21 Nipples .. „	0 1	0 2	0 2	0 3	0 3½	0 4	0 6	0 8	0 10
Round elbows, wrought-iron „	0 7	0 7	0 8	0 9	1 0	1 4	1 11	2 6	3 4
Iron main cocks .. .. .. „	2 3	2 3	2 9	3 6	4 6	6 6	8 6	11 0	14 0
Ditto, with brass plugs .. „	..	..	4 6	5 6	7 6	10 6	15 0	19 6	25 0
Round way iron cocks .. „	..	..	3 6	4 0	5 6	7 6	10 0	13 0	17 6
Ditto, with brass plugs .. „	..	..	5 0	6 6	9 0	13 0	19 0	28 0	36 0
Cock spanners, wrought-iron „	..	..	1 0	1 4	1 8	2 0	2 4	3 0	3 6
Ditto, malleable cast-iron .. „	..	..	0 7	0 8	0 10	1 2	1 8	2 2	2 9
Syphon boxes, 1 quart	..	..	..	11 0	12 0	13 0	14 0	15 0	15 6
Ditto 2 „	..	..	..	..	16 0	17 0	18 0	19 0	21 0
Ditto 3 „	..	..	..	..	20 0	22 0	24 0	25 0	26 6
Ditto 4 „	..	..	..	..	21 0	23 0	25 0	27 0	29 0
Malleable cast round elbows ..	0 6	0 6½	0 7	0 8	0 10	1 2	1 9	2 3	3 0
Socket union, 11 Pipe union ..	..	2 0	2 6	3 0	4 0	5 6	6 9	8 0	9 0
Union bends	..	2 6	3 0	3 9	5 0	6 3	8 6	10 0	11 6

disconnecting old pipes, as the grip is more secure and the labour is reduced.

1 pair of large gas plyers for close small work.
1 12 in. strong shifting spanner for backnuts, &c., &c.
3 or 4 stout brick chisels from 8 in. to 12 in.
1 24 in. steel chisel bar.
1 30 in. stout iron crowbar, for range work, &c.
1 engineer's hammer.
1 heavy hand hammer.
1 trowel each 7 in. and 11 in.
1 14 in. flat bastard file and handle.
1 10 in. half-round ditto.
1 small saw.
1 wood chisel.
1 large screwdriver.
1 soldering-iron.
1 blowpipe.
2 tool bags, paint brush, &c.

The tools enumerated are what may be termed necessaries for a man's proper outfit, but there are several sundry tools that a workman collects, and for repairs to the range if any small part is broken in transit. Handbrace, drills, and taps will be needed.

In addition to this list must be added—

Ratchet brace.
Cramp and brace.
Drills from $\frac{1}{4}$ in. to $1\frac{1}{2}$ in.

for boiler drilling, &c., but these are tools that are generally kept at headquarters, as one set will suffice for three or four pairs of hands. This also applies to the large taps, and it is not usual to have more than one set of taps ($\frac{3}{4}$ in. to $1\frac{1}{4}$ in.) for, say, four sets of stocks and dies.

Such tools as shovel, pail, broom, &c., are generally loaned by the customer, as they are required but little; but sometimes the loan is objected to, and in new build-

ings, of course, pails, &c., do not exist unless the builders are at work on the premises. Tools should be kept scrupulously clean, and care should be exercised to keep them in safety when at work on new buildings, &c. Chisels should be kept sharp, and the lower jaws of tongs should be forged and squared immediately needed, as poor gripping tongs cause great annoyance and loss of time.

CHAPTER XVI.

COMMON FAULTS.

It is not, by far, an uncommon thing to hear complaints made against hot water apparatus; either the water does not heat or it heats too much, or noises are heard in the pipes, and many other annoyances more or less serious. This must proceed, in the majority of cases from a want of skill on the fitter's part, and it is therefore sincerely hoped this work may be the means of providing a better general knowledge of the subject, which is certainly much needed, as has been experienced by everyone who has advertised for "experienced fitters," and seen the host of practically incapable men that apply.

There are very many forms of complaints; but they practically consist of the three following:—

1. Want of hot water.
2. Unpleasant noises.
3. Miscellaneous faults.

These may arise from many various causes, and taking No. 1 first, this may be caused by—

1. Boiler insufficiently powerful for the work.
2. Loss of heat by radiation (common cause).
3. Draw-off services taken from the wrong pipe.
4. Both pipes taken off top of boiler without the dip-pipe, causing imperfect circulation.
5. Retarded circulation caused by "dips" in the flow-pipe; it becomes air locked.
6. Cold supply not being syphoned, so permitting hot

water to travel up it; this is an annoyance in another sense also.

7. Bringing the cold supply into the boiler immediately under the flow.

8. Crossing the pipes so that the pipe that starts from the boiler as the flow is connected to the tank as the return, and *vice versâ*.

9. Retarded circulation caused by an obstacle or stoppage in pipe.

10. Retarded circulation by reason of the flow-pipe starting horizontally from side or back of boiler.

11. Incrustation in boiler or in pipes.

12. Waste of water by long draw-off services; instances are somewhat commonly met with where a tank exists in a high part of the building (as usual), and a draw-off service is taken *from above the tank*. This service is carried down and branched to the various sinks, &c., and no draw-offs are taken from the flow-pipe below the tank. The object aimed at is, without doubt, to attain the safety of the cylinder system in being unable to exhaust the store of water should the supply fail; but the waste of water and heat that ensues is tremendous, as every time a tap is opened this pipe is charged with hot water, which quickly becomes cold, as has already been explained.

13. Retarded circulation by a fall or collection of fur at an angle. This is of common occurrence after workmen have been operating on old pipes, causing the fur to be loosened (if the pipes are furred at all), in such cases the loose fur will often settle down behind the cocks, causing them to become partially or wholly stopped.

Complaint No. 2 may be from the following:—

1. Flow-pipe projecting through top surface of boiler.

2. Expansion projecting through top surface of tank or cylinder, causing air-chambers to be formed.

3. Descending flow-pipe, causing circulation to become air-bound.

4. Boiler being higher in front than at back where pipes are connected, forming air-chamber.

5. Incrustation of pipes.

6. Boiler being too powerful for the work, causing furious boiling, and making more steam than can escape noiselessly.

Miscellaneous faults—

1. Long single draw-off services, causing a quantity of cold water to be drawn before hot is obtained.

2. Draw-off services (cold water) being taken from the cold supply pipe, causing both hot and cold taps to run very slowly when opened together.

3. Taking a draw-off for cold water from the cold supply pipe close to the syphon; result, warm water obtained.

4. Stop-cocks in the primary flow and return; highly dangerous.

5. Putting the stop-cock in the cold supply close to the cistern, instead of down by the cylinder; result, workman have to traverse house two or three times to open and shut the cock.

This list is certainly not complete, but the faults enumerated may be said to embrace all those at all common. The list of uncommon ones would be extremely long, as nearly every complaint brings something novel to light.

CHAPTER XVII.

THE SUPPLY OR BALL VALVE CISTERN; LOW-PRESSURE BOILERS.

THE use of the small cast-iron supply or feed cistern, to be commonly met with in connection with hot-water apparatus, has not been dwelt upon, as it is not now considered a desirable adjunct; and it certainly is not, from the one fact that it involves the use of a ball valve.

Although numberless ball valves have been designed, yet there is not a thoroughly reliable one made to withstand a high pressure, with an arm short enough to go into an ordinary size supply cistern.

It was commonly the practice to put a supply cistern at the side of the tank in the old system, but the practice has been abolished, as it is found to be quite as cheap and much more satisfactory to carry the expansion above the level of the cold water, and so admit of a direct cold supply.

If hot water is not required above the ground or first floor, then it is advisable to use a feed cistern, and so save an unnecessary long length of expansion pipe; but if this is done be sure and have a good sized feed cistern that will admit of a $\frac{1}{2}$-inch ball valve with ordinary length arm being used, as a short armed ball valve will not withstand any but light pressures satisfactorily.

In districts that have the "constant supply," house cisterns are not generally used, and when a hot water apparatus is fitted a cistern for the cold supply has to be

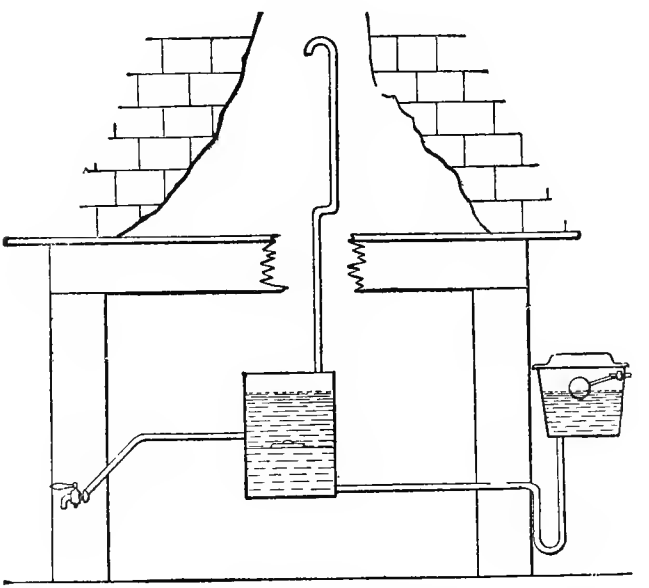
provided. Let this cistern be of good size (say a 10 to 20 gallon galvanized cistern), whatever system is adopted, and see that a thoroughly reliable ball valve with a long arm is used, otherwise trouble will ensue (in speaking of the arm of a ball valve, the rod which has the ball at the end is alluded to; by lengthening the arm a greater leverage is obtained, and a greater pressure can be withstood). Whenever a supply cistern is used it must be fitted with an overflow pipe in the event of the valve leaking (as it will do) or the ball sticking down; this overflow should not be in less than $\frac{3}{4}$-inch pipe, and it is unnecessary to add that it must be carried to a sink or through an outer wall, or to some other convenient position where the overflow of water will be quickly noticed, yet not do damage. Never run an overflow into a rain water, or pipe of any sort, as the pipe may be directly connected with the drains, and furthermore no water company will allow it.

Low-pressure Boilers.—Boilers that are fitted either at the back or at the side of the kitchen range, and which do not supply water above their own level, are known as low-pressure boilers (no-pressure would be a more correct term). These are as various in shape and form as high-pressure boilers, but those most commonly used in modern ranges are either boot-shaped, which go at the back of the fire (the same as high-pressure boot boilers, but without flues); or are square with an open top, very much like a large supply cistern. These latter are generally situated at the side of the fire opposite to the oven.

The boot boilers are heated by the fire coming in contact with the front of the toe. This is found to give quite sufficient heat, and provides abundance of hot water.

When fitting these boilers the supply cistern should be arranged so that the boiler does not fill by some 3 to 4 inches from the top of the leg, as at Fig. 23, otherwise the furious boiling and the quantity of steam generated will cause water to be ejected from the steam pipe; the steam pipe should be fitted as explained in Chapter XIV.

FIG. 23.



The other form of boiler should be filled as nearly as possible quite full, say within one inch of the top; this will leave quite sufficient space for expansion and boiling. There is a common notion that side boilers should not be filled more than three-fourths full. This leaves some

4 inches empty space at the top, which is a grave error, as it is at the top of the boiler where the greatest heat is

FIG. 24.

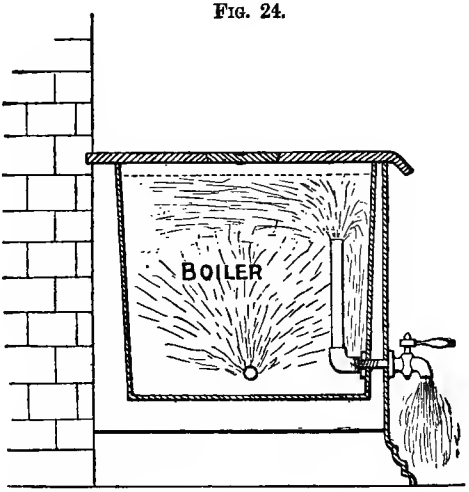
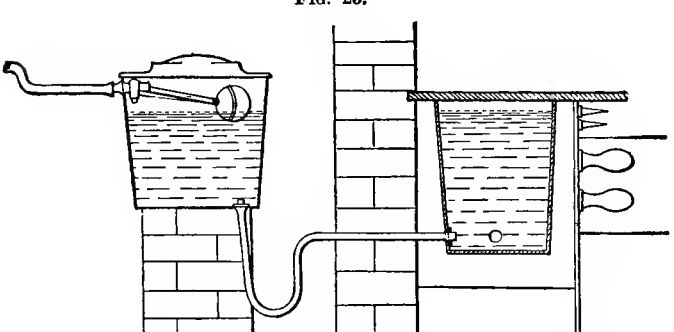


FIG. 25.



felt as the flame leaves the fire, and consequently the top of the boiler will in time become burnt and destroyed. It

is sometimes argued that this amount of space is required for expansion and boiling, but this is wrong, as one inch or an inch and a quarter will be found ample, and the large space is objectionable also, as it lessens the supply of water.

The taps of side boilers are always situated near the bottom of the boiler, and this has a seriously ill effect when the boiler is attached to a self-filling apparatus, as the cold supply is brought into the bottom, and consequently, when the tap is opened and water drawn the cold water immediately flows in, across the bottom of the boiler and out at the tap, and it will be found that although the boiler is full of hot water, yet not more than a third of it can be drawn, as the cold water flowing in keeps the hot water at the top of the boiler by its greater specific gravity. This trouble is overcome in a boot boiler by connecting the draw-off pipe well up the boiler; and in side boilers there are two means of overcoming the difficulty; firstly, by having the tap hole put in a higher position when ordering a new range; and secondly, in an existing range, by putting an elbow and short piece of pipe on the tap *inside* the boiler, so as to draw from the top of the water, as at Fig. 24. This piece of pipe must not be carried up too high, as it must be remembered that the ball valve is probably only $\frac{3}{8}$-in., whereas the tap may be $\frac{3}{4}$-in. Therefore allowance must be made for the outflow being greater than the supply. If the upright piece of pipe is made to come up to about four inches below the water level it will work very satisfactorily. The method of connecting a self-filling apparatus to a side boiler is shown at Fig. 25.

All pipes in connection with boot boilers should not be of less than 1 in. internal diameter, as these boilers cause the water to boil very furiously, and a considerable quantity of fur is deposited with hard water which quickly stops

$\frac{3}{4}$-in. pipes. Pipes that are carried *behind* ranges should never be lead, always iron.

In conclusion, it should be said that hot water work of any and every description should be executed carefully and well, and should not on any account be carried out hurriedly, as any little omission is apt to ruin the whole undertaking.

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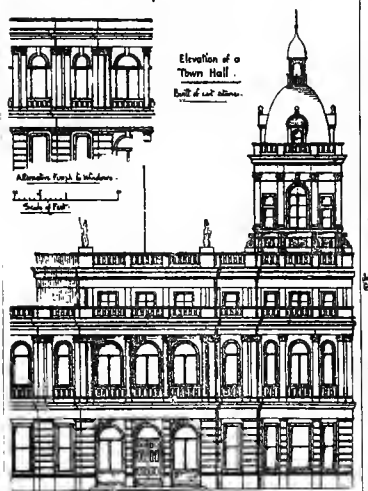

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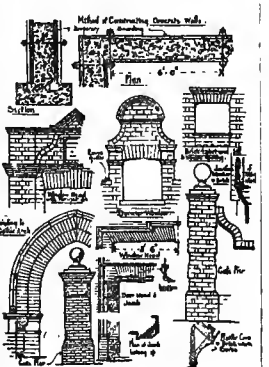

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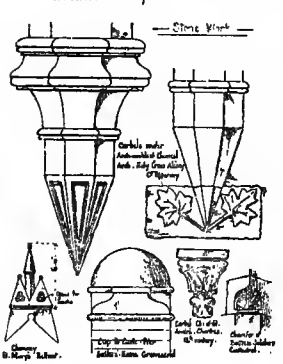

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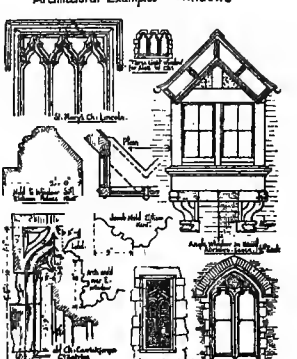

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